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ABSTRACT

An advanced General Education Program has been designed to prepare an individual with the information, concepts, and general knowledge required to successfully pass the American Council on Education's High School General Education Development (GED) Test. The Advanced General Education Program provides comprehensive self-instruction in each of the following areas: (1) Correctness and effectiveness of Expression, (2) Social Studies, (3) Natural Sciences, (4) Interpretation of Literary Materials, and (5) General Mathematics. This document covers atomic structure and chemical change, chemical compounds, and forms of energy. (CK)

PM 431 - 22

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ADVANCED GENERAL EDUCATION PROGRAM

A HIGH SCHOOL SELF-STUDY PROGRAM

ATOMIC STRUCTURE AND CHEMICAL CHANGE

LEVEL: I

UNIT: 7

LESSON: 1

U.S. DEPARTMENT OF LABOR
MANPOWER ADMINISTRATION, JOB CORPS
NOVEMBER 1969

AC014041

U.S. DEPARTMENT OF LABOR
MANPOWER ADMINISTRATION, JOB CORPS
NOVEMBER 1969

4. When elements combine chemically they:

   a. ☐ may lose or gain electrons

   b. ☐ may share electrons

   c. ☐ neither of the above

5. The electrons involved in a chemical reaction are the electrons from:

   a. ☐ the innermost orbit

   b. ☐ the middle orbits

   c. ☐ the outermost orbit

Time completed _____

WHEN YOU HAVE FINISHED THIS TEST, WRITE DOWN THE TIME. THEN TAKE THE LESSON TO YOUR INSTRUCTOR OR HIS ASSISTANT FOR CHECKING. WAIT UNTIL THE LESSON IS APPROVED BEFORE GOING ON TO THE NEXT LESSON.

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In the previous lessons concerning matter, you learned that some elements participate in chemical reactions, but that others do not. Why do you suppose some elements are active and others are inactive? Scientists sought the answer to this question by studying the structures of the atoms of the different elements. They discovered that the structure of an inactive element differs in a characteristic manner from the structure of an active element. They also found that the structure of an atom will determine the different combinations that will be formed by the elements that do combine with one another.

What happens to the elements that participate in a chemical reaction? You have learned that the elements lose their identity when they form a compound, but it is also true that the compound can be broken down and the original elements retrieved. Thus, the elements are not actually lost when they form a compound. Why, then, are they different? And what keeps them together? Are they influenced by the same forces of attraction and repulsion that keep the particles of an atom together?

You may have been wondering why it is important to learn about atoms and molecules in the first place. After all, if they are so small, are we not making our investigations into the laws that govern nature even more difficult? Can we not, in fact, learn more from large bodies of matter? Actually, until the machinery and techniques were discovered which help us observe the effects produced by these smallest bits of matter, scientists could not explain why certain changes took place. It was only by beginning to understand the behavior of atoms and molecules that they formed some fascinating and complex theories about the nature of matter.

Atoms and molecules are not only intricately involved in every physical and chemical change, they also take part in every energy conversion. Did you ever imagine that something as seemingly simple as hearing a pin drop could involve millions of atoms and molecules?

We have talked about the four forms of energy: heat, light, sound, and electricity, and briefly about the conversion of one form of energy to another. Could you describe these four forms of energy to someone well enough to make him understand their difference? For example, could you explain the difference between a sound wave and a light wave? Can they move? How do heat and light travel the 93 million miles across space from the sun to earth?

1. A. If an atom has one orbit, the maximum number of electrons that it can have in its outermost orbit is:

   a. ☐ 0

   b. ☐ 1

   c. ☐ 2

   d. ☐ 8

   e. ☐ any number

   B. If an atom has 2 or more orbits, the maximum number of electrons that it can have in its outermost orbit is:

   a. ☐ 0

   b. ☐ 1

   c. ☐ 2

   d. ☐ 8

   e. ☐ any number

2. The active elements have:

   a. ☐ less than the maximum number of electrons in their outermost orbits

   b. ☐ the maximum number of electrons in their outermost orbits

3. The inactive elements:

   a. ☐ do not have a stable electron pattern

   b. ☐ have a stable electron pattern

You have probably heard the word energy used in many circumstances: mechanical energy for example -- is this simply the energy of machines? You may have heard the terms chemical energy and atomic energy as well. Many news items and magazine articles have pointed to the fact that our natural resources are limited and that it is becoming increasingly necessary to harness the power of the atom. Are they referring to the same energy that is released by an atomic or a hydrogen bomb?

In the following lessons, we will answer some of these questions. But you will not only be learning the answers to some age-old questions, you will be learning more about the world and the exact language that is used to express the new ideas. The more you learn, the more questions there will be -- and the more answers that you will be capable of understanding. Each lesson in science is one more step toward a fuller appreciation and use of the whole world.

Time completed _____

MASTERY TEST

Time started _____

1. PREVIEW FRAME In a previous lesson, we said that of the 103 elements known to man only six elements never combine with other elements to form new substances. In this lesson you will learn why these elements never combine with the other elements. But, before we discuss this chemical change in which two different substances (two elements) become one totally new substance (a compound), let's review what you have learned about atoms. NO RESPONSE REQUIRED	GO ON TO THE NEXT FRAME
2. REVIEW FRAME Atoms are composed of tiny particles called protons, neutrons, and electrons. MATCH the particle with the type of charge that it has: A. electron 1. _____ ○ no charge B. neutron 2. _____ ⊖ negative charge C. proton 3. _____ ⊕ positive charge Because the nucleus of an atom contains protons and usually neutrons, the nucleus as a whole has: ☐ a negative charge ☐ a positive charge ☐ no charge Because the number of protons in the nucleus of an atom is equal to the number of electrons in orbit around the nucleus, the atom as a whole has: ☐ a negative charge ☐ a positive charge ☐ no charge	1. B 2. A 3. C a positive charge no charge

SHARING ELECTRONS	in some chemical reactions, electrons are <u>not</u> actually transferred; they are shared this sharing of electrons is always done in <u>pairs</u>; although electrons are not actually lost or gained, greater stability is still achieved by those atoms that are sharing the electrons

3. Elements may or may not combine to form a new substance when they are mixed together. If they do not combine to form a new substance, the mixing only produces a physical change. When the elements do combine to form a new substance, a chemical change occurs in which case, the elements are said to have reacted chemically. A chemical reaction refers to: ☐ a chemical change ☐ the combining of elements ☐ the mixing but not the combining of elements ☐ a physical change	a chemical change the combining of elements
4. Some elements never react chemically with other elements. Elements that do react chemically are called chemically active elements or, simply, active elements. Elements that do not react chemically are called chemically inactive elements or, simply, inactive elements. Sodium is an element that reacts with many other elements. Sodium is an: ☐ active element ☐ inactive element Neon is an element that never reacts with other elements. Neon is an: ☐ active element ☐ inactive element	active element inactive element

CHEMICAL REACTION	a chemical change in which elements are combined
ACTIVE ELEMENTS	elements that react chemically with other elements; that is, elements that combine with other elements to form a new substance
INACTIVE ELEMENTS	elements that do not react chemically with other elements; of the 103 elements, only 6 are inactive elements
ELECTRONS IN ORBIT	the greatest number of electrons that can ever appear in the first orbit is 2; in the second orbit, 8; in the third, 18; in the fourth, 32; in the fifth, 32; in the sixth, 18; and in the seventh, 8 for any atom with more than one orbit, the greatest number of electrons that can be found in the outermost orbit is 8 for atoms with only 1 orbit, the greatest number of electrons that can be found in that orbit is 2
STABLE ELECTRON PATTERN	a stable electron pattern is one in which there is the maximum number of electrons in the outermost orbit; only 6 elements have a stable electron pattern; these are the chemically stable or inactive elements
UNSTABLE ELECTRON PATTERN	an unstable electron pattern is one in which there is less than the maximum number of electrons in the outermost orbit; the 97 active elements have an unstable electron pattern; these active elements tend to combine chemically with other elements in order to achieve a greater degree of stability
TRANSFERRING ELECTRONS, OR GAINING AND LOSING ELECTRONS	in some chemical reactions, active elements may transfer electrons in order to become more stable; in such a reaction, one element loses electrons while the other element gains those electrons EXAMPLE: when sodium and chlorine react together chemically, sodium gives up one electron and chlorine gains one electron; by doing so, both sodium and chlorine achieve stable electron patterns

5. There are 103 elements. Of these, only 6 never combine with other elements. Thus, the number of active elements is: ☐ 6 ☐ 97 ☐ 103 How many inactive elements are there? _____	 97 6
6. The element sodium is always found in a combined state in nature, whereas the element gold is sometimes found in an uncombined state. Thus, it appears that sodium is: ☐ as active as gold ☐ less active than gold ☐ more active than gold To make a general rule, elements appear to have: ☐ different degrees of activity ☐ the same degree of activity	 more active than gold different degrees of activity
7. The degree of activity of an element is called a <u>chemical property</u>. Elements have other chemical properties which you will learn about in succeeding lessons. Elements have: ☐ different chemical properties ☐ the same chemical properties	 different chemical properties

43.

When a picture shows atoms sharing electrons:

- ☐ the orbits do not overlap
- ☐ the orbits overlap

the orbits overlap

When a picture shows atoms after a transfer of electrons:

- ☐ the orbits do not overlap
- ☐ the orbits overlap

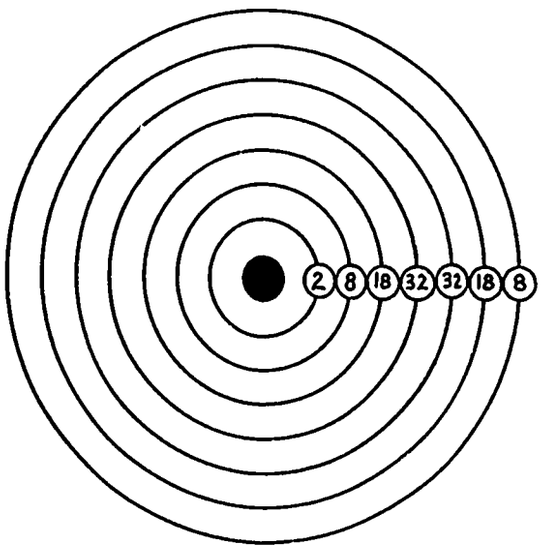
the orbits do not overlap

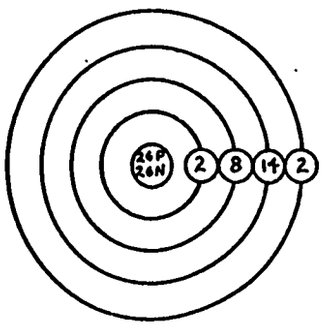
Time completed _____

YOU HAVE NOW FINISHED THE FIRST PART OF THIS LESSON. WRITE DOWN THE TIME. THEN, AFTER YOU HAVE REVIEWED THE MAIN IDEAS IN THE FOLLOWING SUMMARY, TAKE THE MASTERY TEST AT THE END OF THE BOOKLET.

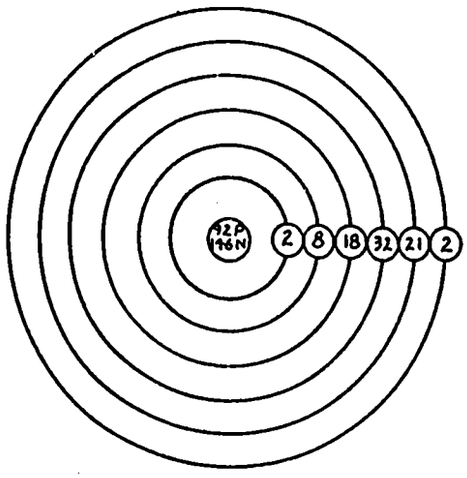
8. The chemical properties of an element: ☐ do not include its degree of activity ☐ include its degree of activity	include its degree of activity
9. MATCH the columns below: A. an active element B. an inactive element 1. _____ reacts chemically with other elements 2. _____ does not react chemically with other elements	1. A 2. B
10. For some time, scientists puzzled over the fact that 6 elements did not take part in chemical changes. What was the reason for their chemical stability? Experimenters centered their investigations on the atoms of the elements hoping to find that the reason for their inactivity had something to do with the structure of their atoms. They found that the atoms of the inactive elements were composed of the same tiny particles: protons and neutrons found in the nucleus of the atom and electrons in their orbits. Scientists then turned their attention to the way in which the electrons distributed themselves in different orbits. NO RESPONSE REQUIRED	GO ON TO THE NEXT FRAME

PANEL 1





IRON



URANIUM

11.

In their investigations, scientists found that the greatest number of electrons that ever appear in the first orbit of an atom is 2; in the second orbit, 8; in the third orbit, 18; in the fourth orbit, 32; in the fifth orbit, 32; in the sixth orbit. 18; and in the seventh orbit, 8.

REFER TO PANEL 1

The facts in the paragraph above are represented in the drawing at the top of the panel. Each circled number in the drawing represents the greatest number of electrons that any one orbit of an atom can have.

The drawings at the bottom of the panel represent an atom of iron and an atom of uranium. The circled numbers in the orbits indicate the electron pattern of the atom; that is, each number shows how many electrons there are in that orbit

What is the greatest number of electrons that the third orbit* of any atom can have? _____ 18

How many electrons are there in the third orbit of the iron atom? _____ . 14

How many electrons are there in the fourth orbit of the iron atom? _____ 2

What is the greatest number of electrons that the fifth orbit of any atom can have? _____ 32

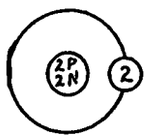
How many electrons are there in the fifth orbit of the uranium atom? _____ 21

How many electrons are there in the sixth orbit of the uranium atom? _____ 2

*Remember that the first orbit is the orbit nearest to the nucleus.

NOTE: Continue with frame 12 on page 11.

PANEL 2



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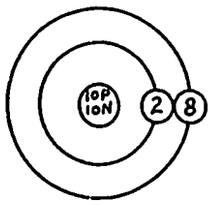
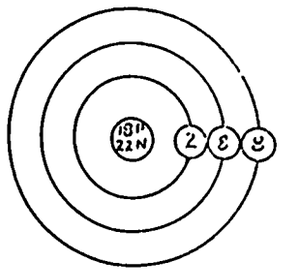
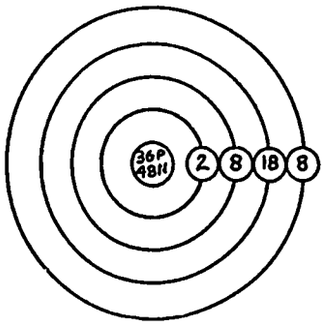


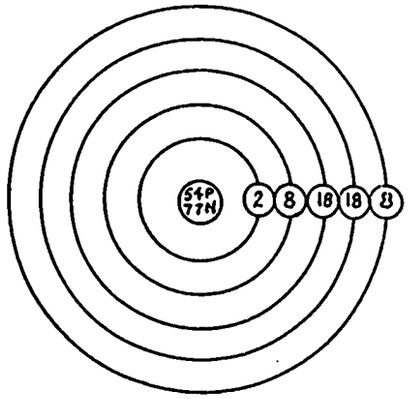
NEON



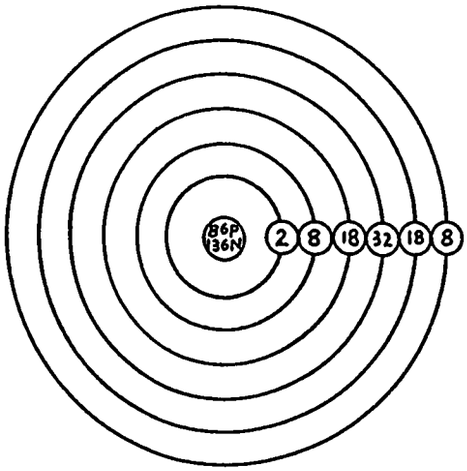
ARGON



KRYPTON

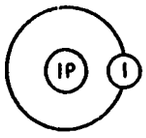


XENON

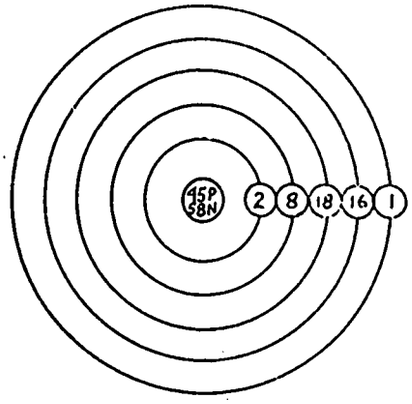


RADON

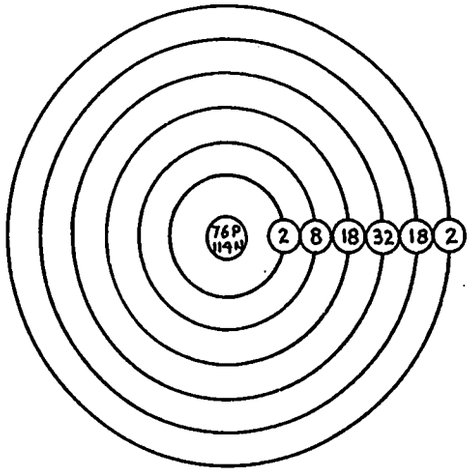
PANEL 2



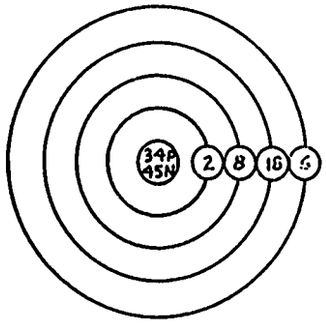
HYDROGEN



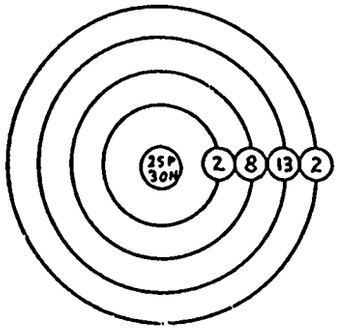
RHODIUM



OSMIUM



SELENIUM



MANGANESE

40. A chemical reaction may involve: ☐ a sharing of electrons between atoms ☐ a transfer of electrons between atoms ☐ neither of the above	 a sharing of electrons . . . a transfer of electrons . . .
41. A chemical reaction involves the transfer and sharing of electrons in: ☐ all the orbits of an atom ☐ the innermost orbits of an atom ☐ the outermost orbits of an atom	 the outermost orbits of an atom In later lessons, we will discuss changes that do involve the other orbits of an atom.
42. REFER TO PANEL 7 (Page 36). The sharing of electrons is represented by a drawing that shows the orbits of the atoms overlapping at the points where the electrons are being shared. The transfer of electrons between atoms can also be represented graphically. In this case, the drawing shows one or more electrons of an atom in the outermost orbit of the other atom; the orbits do not overlap. The transferred electron(s) may be indicated by striped lines. Which drawings on Panel 7 represent a sharing of electrons and which represent a transfer of electrons?	

	sharing	transfer	sharing	transfer
Drawing 1	☐	☐	☒	☐
Drawing 2	☐	☐	☐	☒
Drawing 3	☐	☐	☐	☒
Drawing 4	☐	☐	☒	☐

NOTE: Skip two(2) pages to find page 38.

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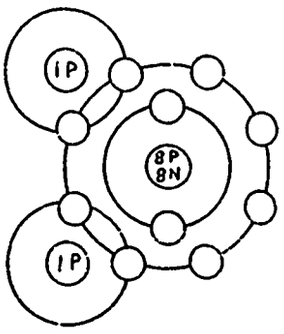
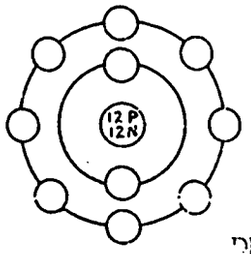
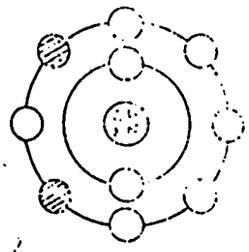
PANEL 7

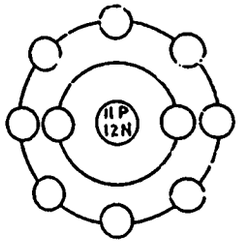


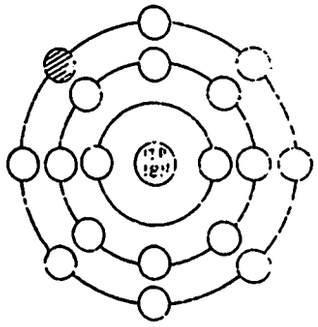
DRAWING 1



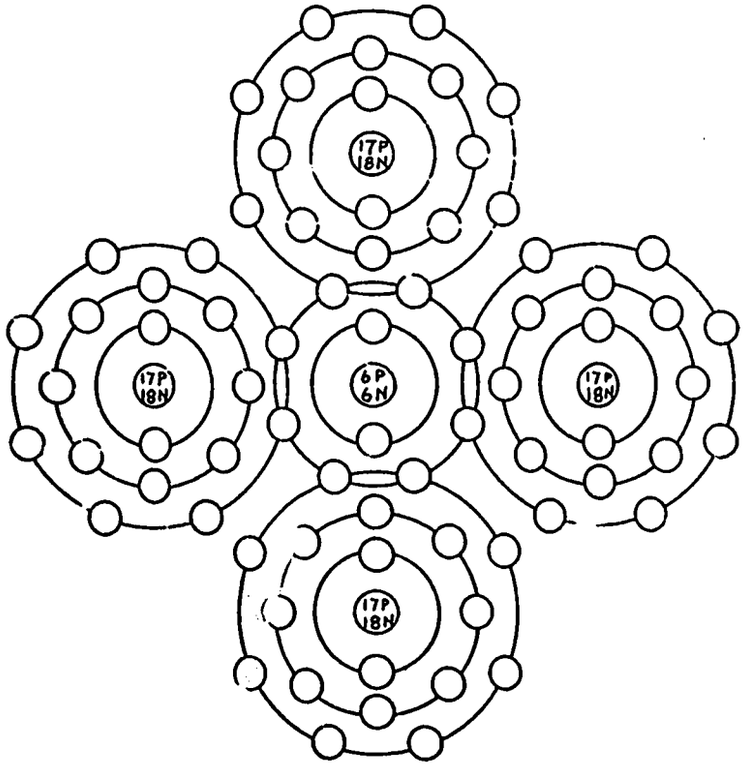


DRAWING 2





DRAWING 3



DRAWING 4

38. When a carbon atom shares 1 of its outermost electrons with a chlorine atom, the carbon atom: ☐ gains an electron ☐ loses an electron ☐ neither gains nor loses an electron and the chlorine atom: ☐ gains an electron ☐ loses an electron ☐ neither gains nor loses an electron When a chlorine atom shares 1 of its outermost electrons with a carbon atom, the chlorine atom: ☐ gains an electron ☐ loses an electron ☐ neither gains nor loses an electron and the carbon atom: ☐ gains an electron ☐ loses an electron ☐ neither gains nor loses an electron	neither gains nor loses . . . neither gains nor loses . . . neither gains nor loses . . .
39. When there is a transfer or sharing of electrons between atoms, the atoms are said to <u>react chemically</u>. The transfer of an electron from the outermost orbit of a sodium atom to the outermost orbit of a chlorine atom: ☐ is a chemical reaction ☐ is not a chemical reaction The sharing of electrons between the outermost orbit of 1 carbon atom and the outermost orbit of 4 chlorine atoms: ☐ is a chemical reaction ☐ is not a chemical reaction	is a chemical reaction is a chemical reaction

12. Comparing the drawings in Panel 1, page 7, it is obvious that an atom: ☐ does not have to have the greatest number of electrons in all inner orbits before it can have electrons in the next outer orbit ☐ must have the greatest number of electrons in all inner orbits before it can have electrons in the next outer orbit	does not have to have the . . .
13. REFER TO PANEL 2 (Pages 9 and 10). Panel 2 shows the electron pattern of various atoms. LOOK AT the outermost orbits of the atoms with more than one orbit. What is the greatest number of electrons that you find in the outermost orbits of these atoms? _____ LOOK AT the outermost orbits of the atoms with only one orbit. What is the greatest number of electrons that you find in the outermost orbits of these atoms? _____	8 2

36. (continued) By sharing a pair of electrons with each 1 of 4 chlorine atoms, the carbon atom has: ☐ a greater degree of stability ☐ no greater degree of stability	a greater degree of stability
37. REFER TO PANEL 6 By sharing a pair of electrons with 1 chlorine atom, the carbon atom has the use of: ☐ 1 more electron ☐ 2 more electrons ☐ 4 more electrons ☐ 8 more electrons If the carbon atom shared a pair of electrons with only 1 chlorine atom, it: ☐ would have an electron pattern similar to neon ☐ would not have an electron pattern similar to neon	1 more electron would not have an electron . . .

14.

Not all the different kinds of atoms with more than one orbit are shown in Panel 2, but if they were shown, you would see that not one atom has an outermost orbit with more than 8 electrons.

Thus, scientists discovered another important fact. For atoms with more than one orbit, 8 appears to be:

- ☐ the greatest number of electrons that can appear in the outermost orbit
- ☐ the least number of electrons that can appear in the outermost orbit
- ☐ neither the greatest nor the least number of electrons that can appear in the outermost orbit

the greatest number of . . .

As it happens, there are only two kinds of atoms with only one orbit; both are shown in Panel 2.

From this fact you can conclude that for atoms with only one orbit 2 is:

- ☐ the greatest number of electrons that can appear in that orbit
- ☐ the least number of electrons that can appear in that orbit
- ☐ neither the greatest nor the least number of electrons that can appear in that orbit

the greatest number of . . .

36. When atoms share electrons, no electrons are actually lost or gained; thus the number of electrons is neither decreased nor increased. However, by sharing electrons atoms do acquire the use of more electrons in their outermost orbits. This use is enough to satisfy their need for a greater degree of stability. REFER TO PANEL 6 (Pages 31 and 32). Drawing 1 of Panel 6 shows 1 atom of carbon and 4 atoms of chlorine. Drawing 2 shows these same atoms with their orbits overlapping at the points where the electrons are being shared. The atoms of the six inactive elements are shown on the left-hand side of the Panel. Suppose the carbon atom shares a pair of electrons with each of the chlorine atoms. The number of electrons in the outermost orbit of each of the chlorine atoms is: ☐ 6 ☐ 7 ☐ 8	7
The number of electrons in the outermost orbit of the carbon atom is: ☐ 0 ☐ 4 ☐ 8	4
With the use of 1 more electron in its outermost orbit, does each chlorine atom have an electron pattern similar to that of argon? ☐ yes ☐ no	yes
By sharing a pair of electrons with the carbon atom, each chlorine atom has: ☐ a greater degree of stability ☐ no greater degree of stability	a greater degree of stability
With the use of 4 more electrons in its outermost orbit (1 shared with each chlorine atom), does the carbon atom have an electron pattern similar to that of neon? ☐ yes ☐ no	yes
(continued on next page)	

15.

For any atom with more than one orbit; in other words, for any atom with anywhere from 2 to 7 orbits, the greatest number of electrons that can be found in the outermost orbit is:

- ☐ 1
- ☐ 2
- ☐ 3-7
- ☐ 8
- ☐ more than 8

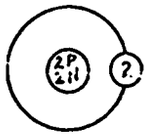
8

For atoms with only one orbit, the greatest number of electrons that can be found in that orbit is:

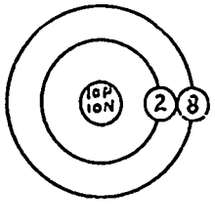
- ☐ 1
- ☐ 2
- ☐ 3-7
- ☐ 8
- ☐ more than 8

2

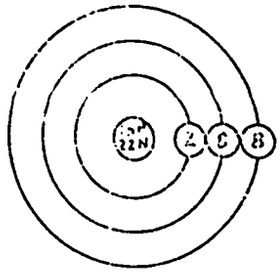
PANEL 6



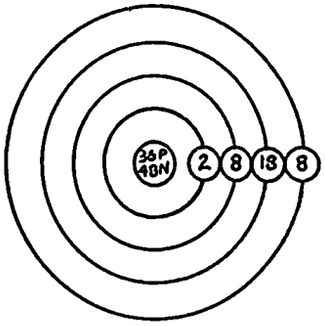
HELIUM



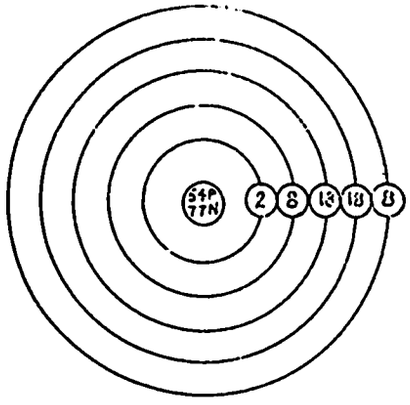
NEON



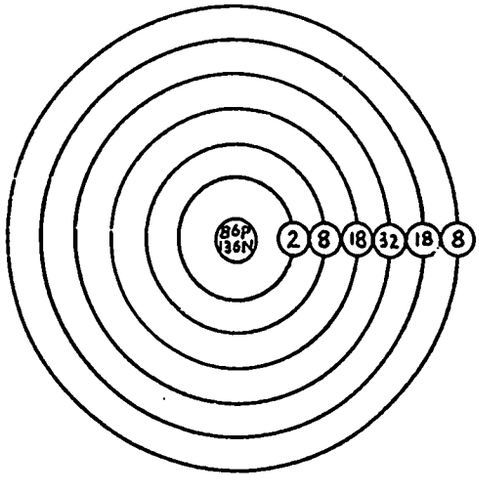
ARGON



KRYPTON



XENON



RADON

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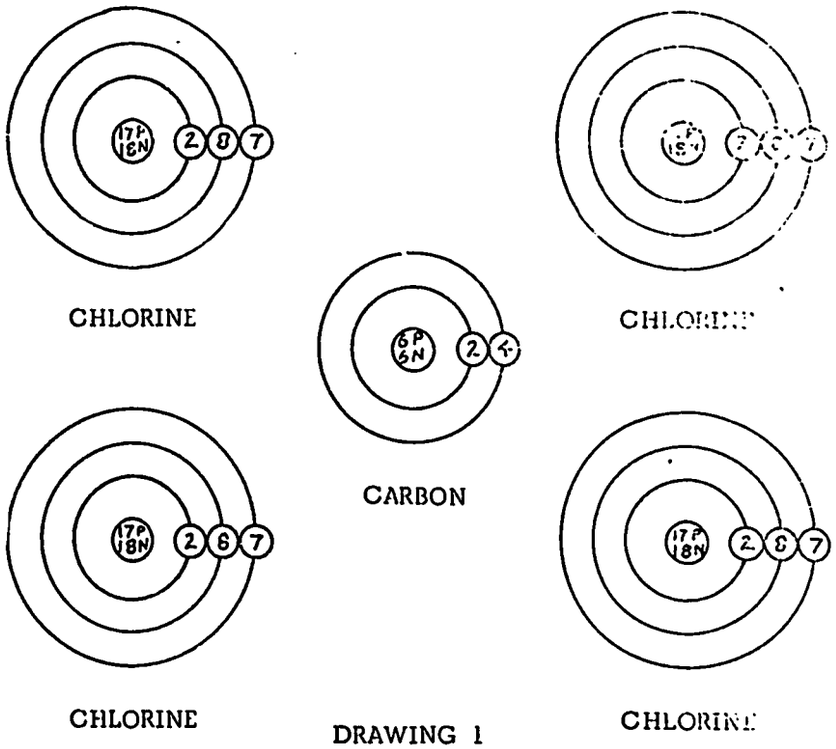
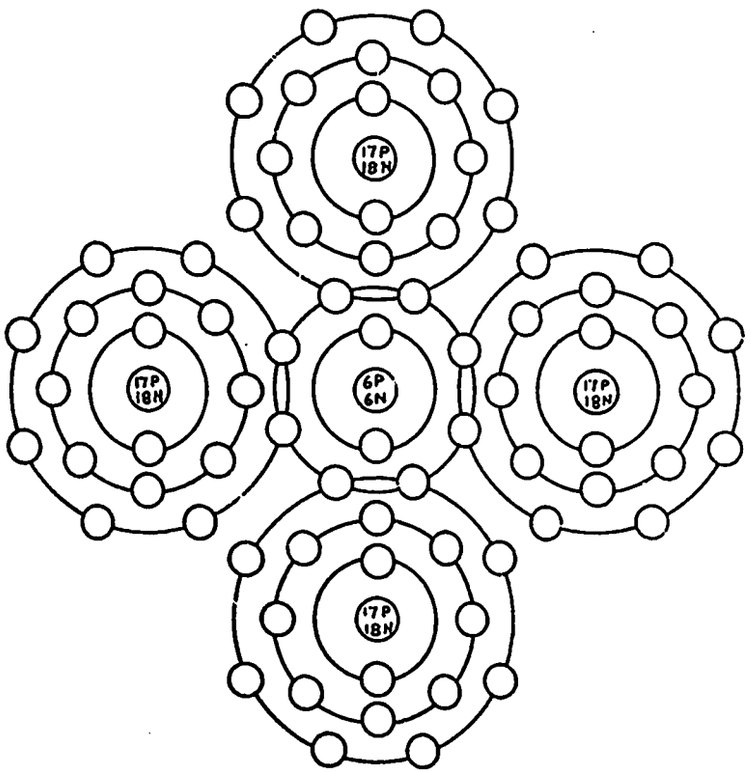
PANEL 6



DRAWING 1



DRAWING 2

35.

Sometimes electrons are shared instead of being transferred. Exactly how electrons are shared between atoms is still unknown. We do know, however, that atoms share <u>pairs</u> of electrons.

REFER TO PANEL 5

Suppose the carbon atom shares 1 of its outermost electrons with 1 chlorine atom, and in return the chlorine atom shares 1 of its outermost electrons with the carbon atom. How many electrons are actually being shared?

- ☐ 1
- ☐ 2
- ☐ 4
- ☐ 7
- ☐ 11

2

How many pairs of electrons are shared between 1 carbon atom and 1 chlorine atom?

- ☐ 1
- ☐ 2
- ☐ 4
- ☐ 7
- ☐ 11

1

Suppose the carbon atom shares 1 of its outermost electrons with 1 chlorine atom, another 1 of its outermost electrons with a second chlorine atom, another 1 of its outermost electrons with a third chlorine atom, and the last available outermost electron with a fourth chlorine atom. How many pairs of electrons does the 1 carbon atom share with the 4 chlorine atoms?

- ☐ 1
- ☐ 2
- ☐ 4
- ☐ 5
- ☐ 8

4

How many pairs of electrons does 1 chlorine atom share with 1 carbon atom?

- ☐ 1
- ☐ 2
- ☐ 4
- ☐ 5
- ☐ 8

1

16.

LOOK AT the electron pattern of the atoms shown on Panel 2.

Which of the elements has an atom with 2 electrons in its outermost orbit?

- ☐ argon
- ☐ helium
- ☐ hydrogen
- ☐ krypton
- ☐ manganese
- ☐ neon
- ☐ osmium
- ☐ radon
- ☐ rhodium
- ☐ selenium
- ☐ xenon

helium

manganese

osmium

Which of the elements has an atom with 8 electrons in its outermost orbit?

- ☐ argon
- ☐ helium
- ☐ hydrogen
- ☐ krypton
- ☐ manganese
- ☐ neon
- ☐ osmium
- ☐ radon
- ☐ rhodium
- ☐ selenium
- ☐ xenon

argon

krypton

neon

radon

xenon

34.

REFER TO PANEL 5

Panel 5 shows 1 atom of carbon and 4 atoms of chlorine.

How many orbits does the carbon atom have? _____ 2
How many electrons are there in its outermost orbit? _____ 4

The carbon atom:

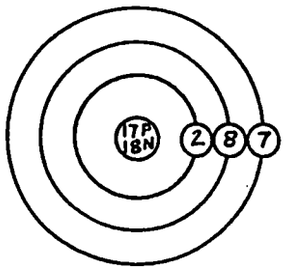
- ☐ does not have the greatest degree of stability possible — does not have the . . .
- ☐ has the greatest degree of stability possible

How many orbits does each chlorine atom have? _____ 3
How many electrons does each chlorine atom have in its outermost orbit? _____ 7

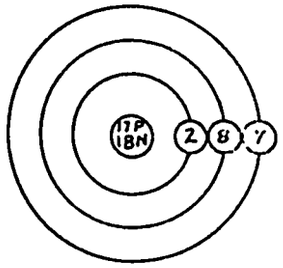
The chlorine atom:

- ☐ does not have the greatest degree of stability possible — does not have the . . .
- ☐ has the greatest degree of stability possible

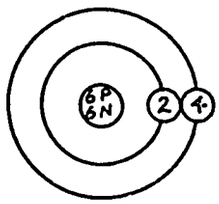
PANEL 5



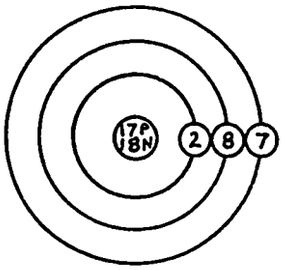
CHLORINE



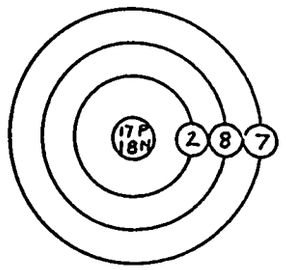
CHLORINE



CARBON



CHLORINE



CHLORINE

32. When a magnesium atom transfers 2 electrons to an oxygen atom, the magnesium atom: ☐ gains electrons ☐ loses electrons ☐ neither gains nor loses electrons and the oxygen atom: ☐ gains electrons ☐ loses electrons ☐ neither gains nor loses electrons Does the number of electrons lost by the magnesium atom equal the number of electrons gained by the oxygen atom? ☐ yes ☐ no	loses electrons gains electrons yes
33. The magnesium atom lost electrons from its: ☐ innermost orbit ☐ outermost orbit The oxygen atom gained electrons in its: ☐ innermost orbit ☐ outermost orbit	outermost orbit outermost orbit

17.

The inactive elements are helium, neon, argon, krypton, xenon, and radon. Helium is the only element with 1 orbit that has 2 electrons in that orbit. Neon, argon, krypton, xenon, and radon are the only elements with 8 electrons in their outermost orbits.

There are:

- ☐ only 6 elements with the maximum number of electrons in their outermost orbits
- ☐ only 97 elements with the maximum number of electrons in their outermost orbits
- ☐ 103 elements with the maximum number of electrons in their outermost orbits

All of the active elements have:

- ☐ less than the maximum number of electrons in their outermost orbits
- ☐ the maximum number of electrons in their outermost orbits

only 6 elements . . .

less than the maximum . . .

18.

MATCH the columns below:

A. the active elements

B. the inactive elements

1. _____ have less than the maximum number of electrons in their outermost orbits

2. _____ have the maximum number of electrons in their outermost orbits

1. A

2. B

31.

Suppose that the magnesium atom transfers its two outermost electrons to the outermost orbit of the oxygen atom.

REFER TO PANEL 4

After the transfer, does the magnesium atom have a third orbit?

- ☐ yes
- ☐ no

no

As a result of the transfer, does the magnesium atom have an electron pattern similar to that of neon?

- ☐ yes
- ☐ no

yes

As a result of the transfer, the magnesium atom:

- ☐ does not have a stable electron pattern
- ☐ has a stable electron pattern

has a stable electron pattern

After the transfer, how many electrons does the oxygen atom have in its outermost orbit? _____

8

With 8 electrons in its outermost orbit, does the oxygen atom have an electron pattern similar to that of neon?

- ☐ yes
- ☐ no

yes

As a result of the transfer, the oxygen atom:

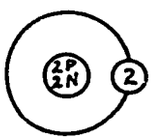
- ☐ does not have a stable electron pattern
- ☐ has a stable electron pattern

has a stable electron pattern

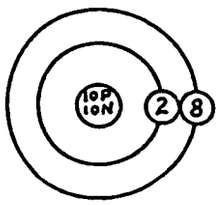
19. Since the inactive elements are chemically stable (that is, do not react chemically with other elements), scientists refer to their electron arrangement as a <u>stable electron pattern</u>. A <u>stable electron pattern</u> is one in which there is: ☐ less than the maximum number of electrons in the outermost orbit ☐ the maximum number of electrons in the outermost orbit The 6 inactive elements are: ☐ not the only elements that have the maximum number of electrons in their outermost orbit ☐ the only elements that have the maximum number of electrons in their outermost orbit It is apparent that all the atoms of the other 97 elements: ☐ do not have a stable electron pattern ☐ have a stable electron pattern	 the maximum number . . . the only elements that have . . . do not have a stable . . .
20. REVIEW FRAME MATCH the columns below: A. the active elements B. the inactive elements 1. _____ do not react chemically 2. _____ react chemically	 1. B 2. A

28. When a sodium atom transfers an electron to a chlorine atom, the sodium atom: ☐ gains an electron ☐ loses an electron ☐ neither gains nor loses an electron and the chlorine atom: ☐ gains an electron ☐ loses an electron ☐ neither gains nor loses an electron	loses an electron gains an electron
29. The number of electrons lost from the outermost orbit of the sodium atom is: ☐ equal to the number of electrons gained by the outermost orbit of the chlorine atom ☐ not equal to the number of electrons gained by the outermost orbit of the chlorine atom	equal to the number of . . .
30. Let's consider another example. REFER TO PANEL 4 (Page 24). Panel 4 shows an atom of magnesium and an atom of oxygen, and the atoms of the 6 inactive elements. How many orbits does the magnesium atom have? _____ How many electrons are there in its outermost orbit?_____ The magnesium atom: ☐ does not have a stable electron pattern ☐ has a stable electron pattern How many orbits does the oxygen atom have? _____ How many electrons are there in its outermost orbit?_____ The oxygen atom: ☐ does not have a stable electron pattern ☐ has a stable electron pattern	3 2 does not have a stable . . . 2 6 does not have a stable . . .

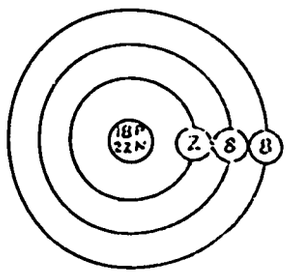
PANEL 4



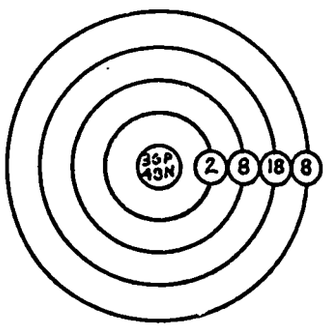
HELIUM



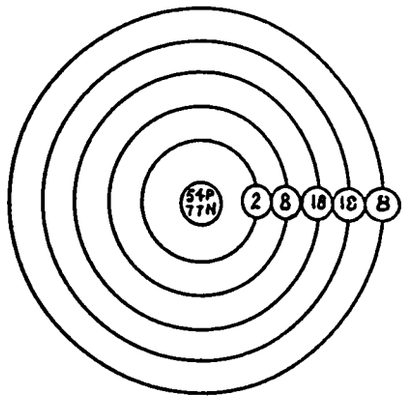
NEON



ARGON



KRYPTON



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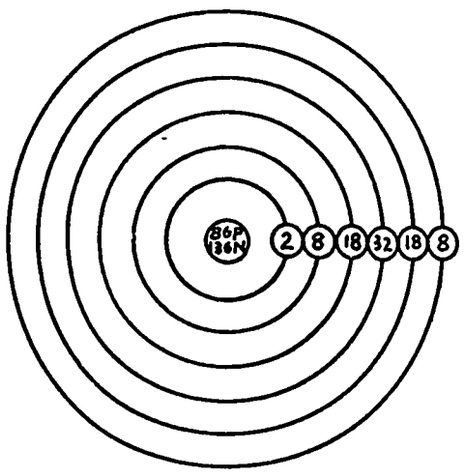
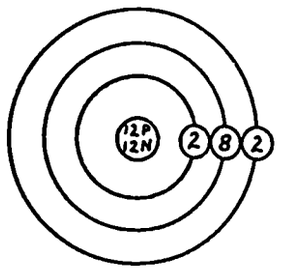
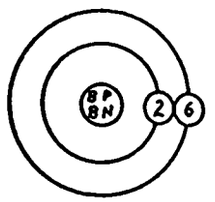


RADON



MAGNESIUM



OXYGEN

27.

Suppose that the sodium atom transfers the electron in its outermost orbit to the outermost orbit of the chlorine atom.

REFER TO PANEL 3

After the transfer, does the sodium atom have a third orbit?

- ☐ yes
- ☐ no

no*

As a result of the transfer, does the sodium atom have an electron pattern similar to that of neon?

- ☐ yes
- ☐ no

yes

As a result of the transfer, the sodium atom:

- ☐ does not have a stable electron pattern
- ☐ has a stable electron pattern

has a stable electron pattern

After the transfer, how many electrons does the outermost orbit of the chlorine atom have? _____

8

With 8 electrons in its outermost orbit, does the chlorine atom have an electron pattern similar to that of argon?

- ☐ yes
- ☐ no

yes

As a result of the transfer, the chlorine atom:

- ☐ does not have a stable electron pattern
- ☐ has a stable electron pattern

has a stable electron pattern

*Recall what we said in a previous lesson: the orbit of an atom is merely the path that an electron follows. Thus, without the electron, there would be no path.

21.

MATCH the columns below:

A. the active elements	1. _____ do not have a stable electron pattern	1. A
B. the inactive elements	2. _____ have a stable electron pattern	2. B

22.

Changes occur in nature so that matter can reach the greatest degree of stability possible.

You would guess that the atoms of the active elements react:

- ☐ because all of the 103 elements tend to change to a stable condition
- ☐ because they have more than 8 electrons in their outermost orbits and this is an unstable condition
- ☐ in order to have an electron pattern similar to the inactive elements which are themselves stable chemically
- ☐ none of the above

in order to have an electron...

26.

All changes occur in nature in the easiest possible manner. This applies to chemical changes as well. Atoms always attempt to reach the stability of one of the inactive elements in the easiest way possible.

REMEMBER that the negatively charged electrons stay in their orbits because they are attracted to the positively charged nucleus.

Now REFER TO PANEL 3.

Which is easier for the sodium atom to do?

- ☐ give away 1 electron and have the stable electron pattern of neon
- ☐ pull away 7 electrons from another atom and have the stable electron pattern of argon

Which is easier for the chlorine atom to do?

- ☐ give away 7 electrons and have the stable electron pattern of neon
- ☐ pull away 1 electron from another atom and have the stable electron pattern of argon

give away 1 electron . . .

pull away 1 electron . . .

23.

MATCH the columns below:

A. react chemically	1. _____ the active elements	1. A, D, F, H
B. do not react chemically	2. _____ the inactive elements	2. B, C, E, G
C. have stable electron patterns		
D. do not have stable electron patterns		
E. have the maximum number of electrons in their outermost orbits		
F. have less than the maximum number of electrons in their outermost orbits		
G. are chemically stable in an uncombined form		
H. combine chemically for a greater degree of stability		

25.

REFER TO PANEL 3 (Page 20).

Panel 3 shows an atom of the element sodium and an atom of the element chlorine, and the atoms of the 6 inactive elements.

LOOK AT the sodium atom. How many orbits does it have? _____ How many electrons are there in its outermost orbit? _____

3
1

The sodium atom:

- ☐ does not have a stable electron pattern
- ☐ has a stable electron pattern

does not have a stable . . .

LOOK AT the chlorine atom. How many orbits does it have? _____ How many electrons are there in its outermost orbit? _____

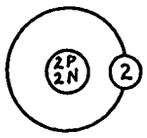
3
7

The chlorine atom:

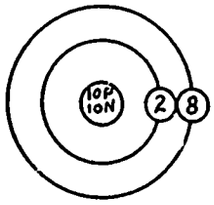
- ☐ does not have a stable electron pattern
- ☐ has a stable electron pattern

does not have a stable . . .

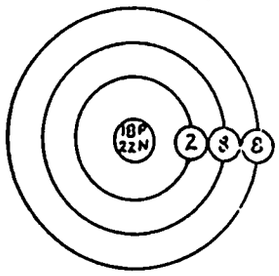
PANEL 3



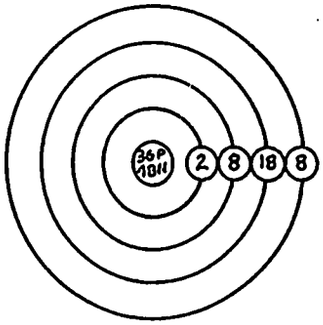
HELIUM



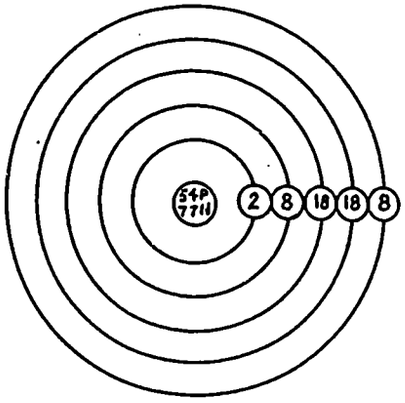
NEON



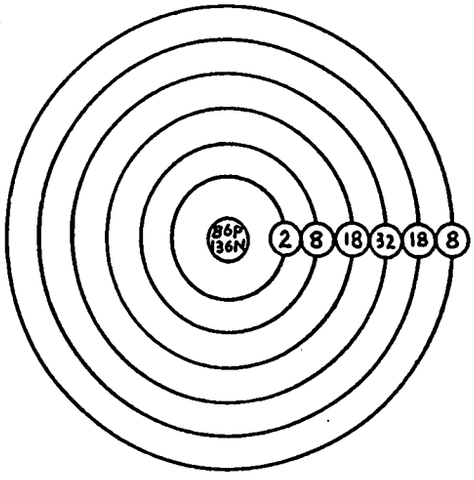
ARGON



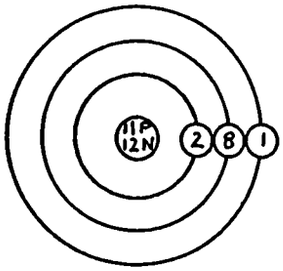
KRYPTON



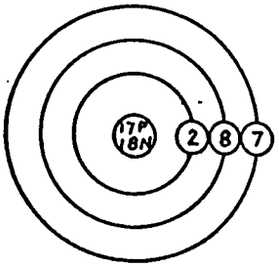
XENON



RADON



SODIUM



CHLORINE

24.

The atoms below are not given names, but you can identify the inactive elements by their stable electron patterns*. PUT AN I in front of the atoms that are chemically inactive, and PUT AN A in front of the atoms that are chemically active.

	number of orbits	number of electrons in the outermost orbit	
_____ Atom R	4	2	A
_____ Atom S	3	8	I
_____ Atom T	3	7	A
_____ Atom U	6	8	I
_____ Atom V	1	1	A
_____ Atom W	4	8	I
_____ Atom X	1	2	I
_____ Atom Y	4	2	A
_____ Atom Z	2	8	I

*The easiest way to identify a stable electron pattern is to note the number of orbits and the number of electrons in the outermost orbit.

PM 431 - 23

ADVANCED GENERAL EDUCATION PROGRAM

A HIGH SCHOOL SELF-STUDY PROGRAM

CHEMICAL COMPOUNDS
LEVEL: I
UNIT: 7
LESSON: 2

U.S. DEPARTMENT OF LABOR
MANPOWER ADMINISTRATION, JOB CORPS
NOVEMBER 1969

U.S. DEPARTMENT OF LABOR
MANPOWER ADMINISTRATION, JOB CORPS
NOVEMBER 1969

1. PREVIEW FRAME In the last lesson you learned that some elements gain, lose, or share electrons from their outermost orbit. When they do this, we say that a chemical reaction has taken place. In this lesson, you will see what happens to the atoms of elements that take part in a chemical reaction. NO RESPONSE REQUIRED	GO ON TO THE NEXT FRAME
2. REVIEW FRAME An atom as a whole has: ☐ a negative charge ☐ a positive charge ☐ no charge because the number of its protons and the number of its electrons is: ☐ different ☐ the same Electrons are gained or lost by atoms when electrons are: ☐ shared ☐ transferred Electrons are neither gained nor lost by atoms when electrons are: ☐ shared ☐ transferred An electron is a: ☐ negatively charged particle ☐ particle with no charge ☐ positively charged particle	no charge the same transferred shared negatively charged particle

4. A. An elemental molecule is formed by atoms of:

a. ☐ different elements

b. ☐ the same element

B. CIRCLE the symbol below that represents an elemental molecule:

a. 2NaCl

b. Br_2

c. H_2O

d. 2K

5. MATCH the columns below:

A. a formula representing analysis	1. _____ KCl
B. a formula representing synthesis	2. _____ $2Ag_2O$
C. 1 molecule of a compound	3. _____ 2Na
D. 1 molecule of an element	4. _____ O_2
E. 2 atoms of an element	5. _____ $4Ag + O_2 \rightarrow 2Ag_2O$
F. 2 molecules of a compound	6. _____ $2KCl \rightarrow 2K + Cl_2$

Time completed _____

WHEN YOU HAVE FINISHED THIS TEST, WRITE DOWN THE TIME. THEN TAKE THE LESSON TO YOUR INSTRUCTOR OR HIS ASSISTANT FOR CHECKING. WAIT UNTIL THE LESSON IS APPROVED BEFORE GOING ON TO THE NEXT LESSON.

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3. When an atom loses an electron, it loses: ☐ a negatively charged particle ☐ a positively charged particle When an atom gains an electron, it gains: ☐ a negatively charged particle ☐ a positively charged particle	a negatively charged particle a negatively charged particle
4. When an atom loses a negatively charged particle, the number of its positively charged particles is: ☐ greater than the number of its remaining negatively charged particles ☐ smaller than the number of its remaining negatively charged particles As a consequence, you would expect the atom as a whole to acquire: ☐ a negative charge ☐ a positive charge ☐ no charge	greater than the number . . . a positive charge
5. When an atom gains a negatively charged particle, the number of its positively charged particles is: ☐ greater than the number of its negatively charged particles ☐ smaller than the number of its negatively charged particles As a consequence, you would expect the atom as a whole to acquire: ☐ a negative charge ☐ a positive charge ☐ no charge	smaller than the number . . . a negative charge

1. An ion:

   a. ☐ may have a greater number of negatively charged particles

   b. ☐ may not have a greater number of negatively charged particles

   c. ☐ may have a greater number of positively charged particles

   d. ☐ may not have a greater number of positively charged particles

2. A. Which bond is formed by a transfer of electrons?

   a. ☐ an ionic bond

   b. ☐ a non-ionic bond

   B. Which bond is formed by a sharing of electrons?

   a. ☐ an ionic bond

   b. ☐ a non-ionic bond

3. A molecule has:

   a. ☐ a negative charge

   b. ☐ a positive charge

   c. ☐ no charge

6. When there is a transfer of electrons between atoms: ☐ atoms gain electrons ☐ atoms lose electrons ☐ atoms neither gain nor lose electrons When there is a sharing of electrons between atoms: ☐ atoms gain electrons ☐ atoms lose electrons ☐ atoms neither gain nor lose electrons	atoms gain electrons atoms lose electrons atoms neither gain nor lose . . .
7. When an atom as a whole acquires a positive or a negative charge, it is called an <u>ion</u>. A transfer of electrons between atoms: ☐ changes the atoms into ions ☐ does not change the atoms into ions A sharing of electrons between atoms: ☐ changes the atoms into ions ☐ does not change the atoms into ions	changes the atoms into ions does not change the atoms . . .
8. When an atom loses one or more electrons, it acquires: ☐ a negative charge ☐ a positive charge When an atom gains one or more electrons, it acquires: ☐ a negative charge ☐ a positive charge	 a positive charge a negative charge

MASTERY TEST

Time started _____

53

9. An atom that acquires a positive charge is called a positively charged ion. An atom that acquires a negative charge is called a negatively charged ion. In the reaction between sodium and chlorine, sodium transfers an electron to chlorine. Therefore, sodium: ☐ becomes a negatively charged ion ☐ becomes a positively charged ion ☐ does not become an ion and chlorine: ☐ becomes a negatively charged ion ☐ becomes a positively charged ion ☐ does not become an ion	becomes a positively charged ion becomes a negatively charged ion
10. In the reaction between carbon and chlorine atoms, electrons are shared. Therefore, carbon: ☐ becomes a negatively charged ion ☐ becomes a positively charged ion ☐ does not become an ion and each chlorine atom: ☐ becomes a negatively charged ion ☐ becomes a positively charged ion ☐ does not become an ion	does not become an ion does not become an ion

ANALYSIS	a chemical change that involves the <u>decomposing</u> of a compound into 2 or more substances, usually elements EXAMPLE: $2KCl \rightarrow 2K + Cl_2$
ENERGY CHANGES	some quantity of energy (in the form of heat) is <u>always</u> absorbed or liberated during a chemical reaction

11. A positively charged ion is an atom that: ☐ has gained one or more electrons ☐ has lost one or more electrons ☐ has neither lost nor gained electrons A negatively charged ion is an atom that: ☐ has gained one or more electrons ☐ has lost one or more electrons ☐ has neither lost nor gained electrons	has lost one or more electrons has gained one or more electrons
12. REVIEW FRAME Particles with opposite charges: ☐ attract one another ☐ repel one another ☐ neither attract nor repel one another	attract one another
13. As a result of a transfer of electrons, the atoms involved: ☐ become ions with the same charge ☐ become ions with opposite charges ☐ do not become ions You would expect, therefore, that the atoms would: ☐ attract one another ☐ repel one another ☐ neither attract nor repel one another	become ions with opposite... attract one another

MOLECULE	the smallest part of a compound is called a molecule EXAMPLE: H_2O is the symbol for one molecule of water
ELEMENTAL MOLECULES	molecules that are formed by combining two or more atoms of the same element
CHEMICAL FORMULA	each compound has a name and a symbol combining sodium and chlorine produces sodium chloride (salt); the symbol for the compound sodium chloride is made by placing the symbol for sodium (Na) next to the symbol for chlorine (Cl): NaCl = sodium chloride; NaCl is the formula for sodium chloride
RULES FOR SYMBOLS	1. more than one atom of an element is shown by placing a number in front of the symbol for that atom EXAMPLE: 3 atoms of hydrogen = 3H 2. when an atom is part of a molecule, we indicate more than one atom by placing a number to the right and below the symbol for that atom EXAMPLE: water has 2 hydrogen atoms: H_2O 3. more than one molecule is shown by placing a number in front of the formula for that molecule EXAMPLE: 3 molecules of water = $3H_2O$
CHEMICAL EQUATION	a statement that uses the correct symbols and formulas to show that a chemical change or reaction has taken place EXAMPLE: $2Na + Cl_2 \rightarrow 2NaCl$
SYNTHESIS	a chemical change that involves the combining of 2 or more substances, usually elements, to form a compound EXAMPLE: $2Na + Cl_2 \rightarrow 2NaCl$

14.

By sharing electrons, the atoms involved:

- ☐ become ions with the same charge
- ☐ become ions with opposite charges
- ☐ do not become ions

do not become ions

You would expect, therefore, that atoms sharing electrons would:

- ☐ attract one another
- ☐ repel one another
- ☐ neither attract nor repel one another

neither attract nor repel . . .

15.

Because atoms become ions after a transfer of electrons, they do not separate. The attraction that their unlike charges have for each other is the basis of an association which keeps them together. This association is called an ionic bond.

Though atoms that share electrons do not become ions, the fact that they are sharing electrons is the basis of the association that keeps them united. This association is called a non-ionic bond.

An ionic bond is created by:

- ☐ the sharing of electrons between 1 carbon atom and 4 chlorine atoms
- ☐ the transfer of an electron from a sodium atom to a chlorine atom

the transfer of an electron . . .

- ☐ neither of the above

A non-ionic bond is created by:

- ☐ the sharing of electrons between 1 carbon atom and 4 chlorine atoms

the sharing of electrons . . .

- ☐ the transfer of an electron from a sodium atom to a chlorine atom
- ☐ neither of the above

ION	an atom has no electric charge; this is because the number of electrons equals the number of protons in any one atom; but if electrons are lost or gained (transferred during a chemical reaction), there is no longer a balance between electrons and protons if an atom loses electrons, it then has more protons (+ particles) than electrons (- particles) and it, therefore, acquires a positive charge if an atom gains electrons, it then has more electrons (- particles) than protons (+ particles) and it, therefore, acquires a negative charge when an atom acquires a positive or a negative charge, it is then called an <u>ion</u>
POSITIVELY CHARGED ION	an atom with a positive charge (more protons than electrons)
NEGATIVELY CHARGED ION	an atom with a negative charge (more electrons than protons)
IONIC BOND	during a transfer of electrons (chemical reaction), one atom gives up electrons (becomes a positively charged ion) and the other atom gains those electrons (becomes a negatively charged ion); these ions, with their opposite charges, are <u>attracted</u> to one another; this association between oppositely charged ions is called an <u>ionic bond</u>
NON-IONIC BOND	atoms that only <u>share</u> electrons during a chemical reaction do <u>not</u> become ions; this is because no electrons are actually lost or gained by the atoms; this <u>sharing</u> of electrons is what keeps the atoms together, <u>not</u> an attraction between oppositely charged ions; such an association is called a <u>non-ionic bond</u>
COMPOUND	when the atoms of two or more <u>different</u> elements are bonded together chemically (either by a transfer or a sharing of electrons), they form a <u>compound</u> EXAMPLE: Hydrogen + Oxygen = Hydrogen Oxide (water); Hydrogen Oxide is a compound

16. A transfer of electrons between atoms: ☐ creates an ionic bond ☐ creates a non-ionic bond ☐ does not create a bond A sharing of electrons between atoms: ☐ creates an ionic bond ☐ creates a non-ionic bond ☐ does not create a bond	creates an ionic bond creates a non-ionic bond
17. Sodium is a soft, silvery metal with a bright luster. It is a very active element; it is never found in an uncombined state in nature. Chlorine is a yellowish-green gas with a disagreeable odor. It is irritating to the nasal passageways. Chlorine is also never found free in nature since it is a very active element. Sodium and chlorine: ☐ are the same substance ☐ are different substances ☐ have the same properties ☐ have different properties	are different substances have different properties

43.

From what you have just learned about elements, compounds, and chemical reactions, would you say that:

- ☐ chemical changes have a significant relation to everyday experiences
- ☐ chemical changes have very little relation to everyday experiences
- ☐ many different kinds of matter are formed or decomposed by the chemical changes that occur
- ☐ not many different kinds of matter are formed or decomposed by the chemical changes that occur

chemical changes have a . . .

many different kinds of matter . . .

44.

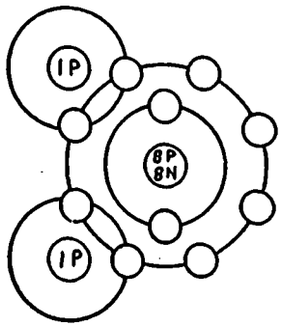
We have just briefly indicated the fact that changes in matter also involve changes in energy. In the next lesson, you will begin to realize how closely matter and energy are related, and how they take part in every change that occurs.

Time completed _____

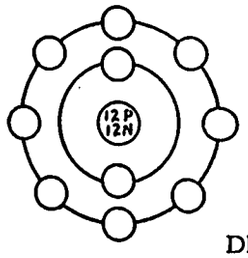
YOU HAVE NOW FINISHED THE FIRST PART OF THIS LESSON. WRITE DOWN THE TIME. THEN, AFTER YOU HAVE REVIEWED THE MAIN IDEAS IN THE FOLLOWING SUMMARY, TAKE THE MASTERY TEST AT THE END OF THE BOOKLET.

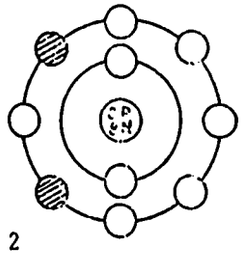
18. When the atoms of 2 or more elements are bonded together (either by a transfer or a sharing of electrons), they form a <u>compound</u>. The smallest part of a compound is called a <u>molecule</u>. When an atom of sodium and an atom of chlorine combine chemically, they form a new substance called sodium chloride. (Sodium chloride is the chemical name for table salt.) Sodium chloride is: ☐ a compound ☐ an element The smallest part of sodium chloride is: ☐ an atom ☐ a molecule	a compound a molecule
19. A compound is formed by: ☐ 2 or more elements that have chemically combined ☐ 2 or more elements that have not chemically combined A compound may be formed by: ☐ the sharing of electrons ☐ the transfer of electrons ☐ neither the sharing nor the transfer of electrons	2 or more elements that have . . . the sharing of electrons the transfer of electrons

PANEL 1

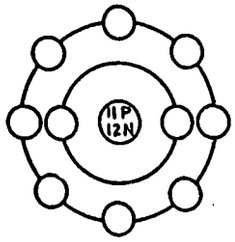


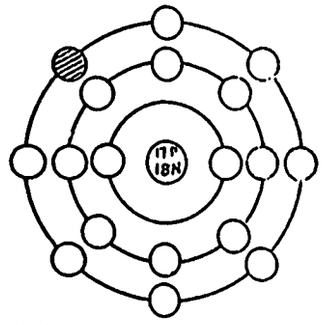
DRAWING 1



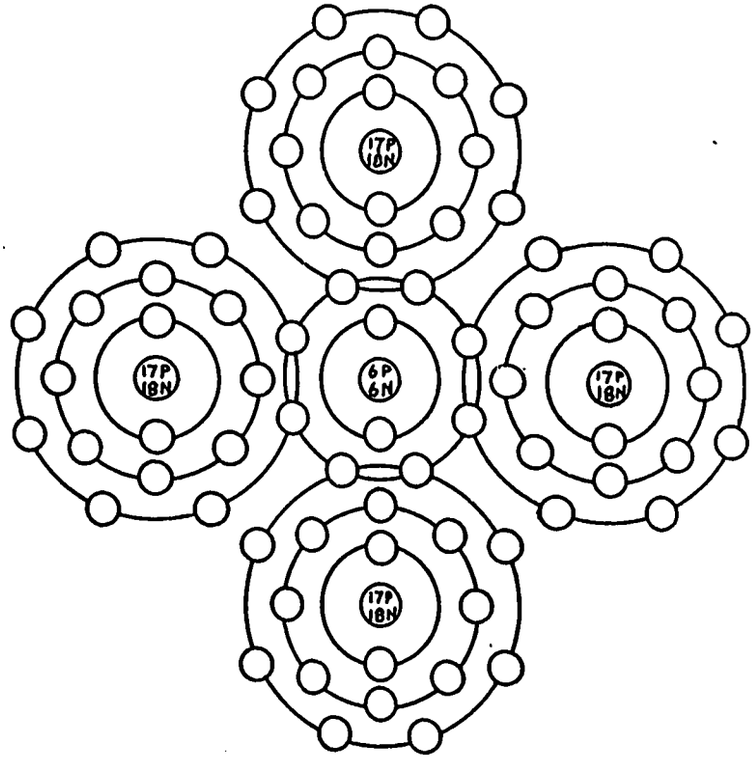


DRAWING 2





DRAWING 3



DRAWING 4

20. REFER TO PANEL 1 (Page 9). The compounds represented on Panel 1 are: sodium chloride (salt), hydrogen oxide (water), magnesium oxide, and carbon tetrachloride. How many molecules are shown on Panel 1? ☐ 4 ☐ 6 ☐ 11 The drawings on Panel 1 show that a molecule may consist of: ☐ 2 atoms ☐ 3 atoms ☐ 5 atoms	4 2 atoms 3 atoms 5 atoms
21. Actually, a molecule may be composed of 2 to several hundred atoms, in hundreds of different arrangements. You can guess that there are: ☐ innumerable compounds ☐ only a few compounds A molecule: ☐ consists of atoms ☐ is the same as an atom	innumerable compounds consists of atoms
22. A molecule may be formed by: ☐ an ionic bond ☐ a non-ionic bond ☐ neither of the above	an ionic bond a non-ionic bond

41. When two elements <u>combine</u> to form a compound, we call the chemical reaction that takes place: ☐ analysis ☐ synthesis ☐ neither of the above When a compound decomposes into 2 elements, we call the chemical reaction that takes place: ☐ analysis ☐ synthesis ☐ neither of the above	synthesis analysis
42. Whenever atoms combine to form molecules, there is an energy change. Whenever molecules break down into atoms (and these atoms possibly combine again with the atoms of another element) there is an energy change. The change in energy always involves a quantity of heat; and, if the heat is sufficient, light. But regardless of what kind of reaction occurs, some quantity of energy is always absorbed or liberated from a chemical reaction. Analysis and synthesis: ☐ always involve the absorption or liberation of energy in the form of heat ☐ sometimes involve the absorption or liberation of energy in the form of heat ☐ never involve the absorption or liberation of energy in the form of heat	always involve the absorption . . .

23. A molecule formed by an ionic bond contains atoms that: ☐ are negatively charged ions ☐ are positively charged ions ☐ are sharing electrons ☐ do not have a charge ☐ have gained or lost 1 or more electrons A molecule formed by a non-ionic bond contains atoms that: ☐ are negatively charged ions ☐ are positively charged ions ☐ are sharing electrons ☐ do not have a charge ☐ have gained or lost 1 or more electrons	are negatively charged ions are positively charged ions have gained or lost . . . are sharing electrons do not have a charge
24. REVIEW FRAME MATCH the sign with the charge that it is used to represent. A. negative charge 1. _____ ⊖ B. positive charge 2. _____ ⊕ C. no charge 3. _____ ○	1. C 2. A 3. B

38. A chemical change also occurs when a compound is broken up or decomposed into two or more substances, usually elements. LOOK AT the equation below. $2HgO \longrightarrow 2Hg + O_2$ The equation indicates that: ☐ a compound has decomposed into 2 elements ☐ 2 elements have combined to form a compound ☐ no chemical change has taken place	a compound has decomposed . . .
39. A chemical change may involve: ☐ the combining of two substances, usually elements, to form a compound ☐ the decomposing of a compound into 2 or more substances, usually elements ☐ neither of the above	the combining of two . . . the decomposing of a . . .
40. A chemical change that involves the combining of two substances, usually elements, to form a compound is called <u>synthesis</u>. A chemical change that involves the decomposing of a compound into 2 or more substances, usually elements, is called <u>analysis</u>. MATCH the equation with the type of chemical change that it indicates: A. $4Al + 3O_2 \longrightarrow 2Al_2O_3$ 1. _____ analysis B. $2KClO_3 \rightarrow 2KCl + 3O_2$ 2. _____ synthesis	1. B 2. A

25. When a sodium atom and a chlorine atom combine chemically, the number of negatively charged particles lost by the sodium atom is: ☐ equal to the number of negatively charged particles gained by the chlorine atom ☐ not equal to the number of negatively charged particles gained by the chlorine atom	equal to the number . . .
26. The sodium atom has lost 1 electron. Thus, the number of its positively charged particles exceeds the number of its negatively charged particles by 1. We can indicate this fact by saying that the sodium ion has a positive charge of +1. The chlorine atom has gained 1 electron. Thus, the number of its negatively charged particles exceeds the number of its positively charged particles by 1. We can indicate this fact by saying that the chlorine ion has a negative charge of -1. A molecule of sodium chloride is formed when a sodium atom transfers one of its electrons to a chlorine atom. A molecule of sodium chloride is composed of: ☐ atoms with no charge ☐ an ion with a charge of +1 ☐ an ion with a charge of -1 In a molecule of sodium chloride, the number of positive charges is: ☐ equal to the number of negative charges ☐ not equal to the number of negative charges Thus, the molecule of sodium chloride has: ☐ a negative charge ☐ a positive charge ☐ no charge	an ion with a charge of +1 an ion with a charge of -1 equal to the number of . . . no charge

37.

Salt is a compound whose molecules are composed of a sodium atom and a chlorine atom. Under certain conditions, we can break up a molecule of salt into the elements that it is composed of: sodium and chlorine.

Sodium and chlorine are:

- ☐ the same substance
- ☐ two different substances

two different substances

When a sodium atom combines with a chlorine atom:

- ☐ a new substance is produced
- ☐ no new substance is produced

a new substance is produced

Sodium chloride is:

- ☐ the same as sodium
- ☐ the same as chlorine
- ☐ a third substance

a third substance

When a sodium atom combines with a chlorine atom, a chemical change:

- ☐ occurs
- ☐ does not occur

occurs

When sodium chloride is changed back to sodium and chlorine, we have:

- ☐ 1 substance
- ☐ 2 substances
- ☐ 3 substances

2 substances

When a substance is changed back into the original substances that it was composed of, a chemical change:

- ☐ occurs
- ☐ does not occur

occurs

27.

Like sodium chloride, every other molecule formed by an ionic bond has an equal number of positive and negative charges.

Generally, then, a molecule formed by an ionic bond has:

- ☐ a negative charge
- ☐ a positive charge
- ☐ no charge

no charge

Is a molecule formed by a non-ionic bond composed of charged atoms?

- ☐ yes
- ☐ no

no

Thus, a molecule formed by a non-ionic bond has:

- ☐ a negative charge
- ☐ a positive charge
- ☐ no charge

no charge

28.

Up to now we have used the word molecule only to refer to the smallest part of a compound (that is, atoms of two or more elements chemically combined). Actually, there are cases in which two or more atoms of the same element also form a molecule.

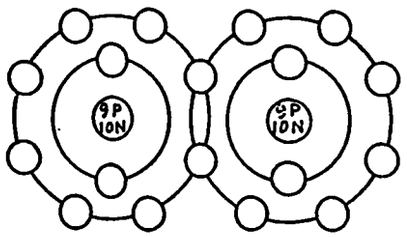
For example, an oxygen atom, in order to have a greater degree of stability, will always share 2 electrons with another oxygen atom.

Thus, a molecule may be formed by:

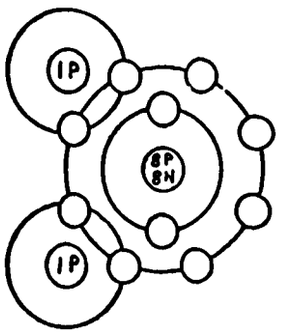
- ☐ atoms of the same element
- ☐ atoms of two or more different elements
- ☐ neither of the above

atoms of the same element
atoms of two or more ...

PANEL 2



DRAWING 1



DRAWING 2

29.

We refer to the molecules that are formed by atoms of the same element as elemental molecules in order to distinguish them from the molecules formed by atoms of 2 or more elements.

REFER TO PANEL 2 (Page 14).

LOOK AT the number of protons indicated in each nucleus of Drawing 1. The atomic number of each atom is:

- ☐ different
- ☐ the same

the same

The atoms in Drawing 1 represent:

- ☐ different elements
- ☐ the same element

the same element

The atoms in Drawing 1 represent:

- ☐ an elemental molecule
- ☐ a molecule of a compound

an elemental molecule

LOOK AT the number of protons indicated in the nucleus of Drawing 2. The atomic number of each atom is:

- ☐ different
- ☐ the same

different

The atoms in Drawing 2 represent:

- ☐ different elements
- ☐ the same element

different elements

The atoms in Drawing 2 represent:

- ☐ an elemental molecule
- ☐ a molecule of a compound

a molecule of a compound

36.

A statement which uses the appropriate symbols and formulas to indicate that a chemical change has taken place is called a chemical equation.

LOOK AT the equation below.

$$2Na + Cl_2 \longrightarrow 2NaCl$$

The equation indicates that:

- ☐ 2 elements have combined to form a compound
- ☐ 2 molecules have combined to form a compound
- ☐ no change has taken place

2 elements have combined . . .

30.

An elemental molecule is composed of atoms:

☐ of different elements
☐ of the same element

of the same element

A molecule of a compound is composed of atoms:

☐ of different elements
☐ of the same element

of different elements

31.

Each element has a name and a symbol. Each compound also has a name and a symbol.

In a previous frame, we said that the chemical combination of sodium and chlorine produced a new substance called sodium chloride, commonly known as salt. We can indicate the fact that salt is composed of sodium and chlorine by writing the symbol for sodium (Na) next to the symbol for chlorine (Cl). The result (NaCl) is called a chemical formula.

MATCH the columns below:

A. Mg
B. MgO
C. O

1. _____ symbol for the element oxygen
2. _____ symbol or formula for the compound magnesium oxide
3. _____ symbol for the element magnesium

1. C
2. B
3. A

Turn to back cover to find frame 32 on page 17.

34.

LOOK AT PANEL 3 (Page 18).

A molecule of lithium oxide is represented on the Panel. An atom of lithium (Li) is smaller than an atom of oxygen (O).

How many lithium atoms are there? _____ 2

How many oxygen atoms are there? _____ 1

The proper formula for this molecule is:

- ☐ 3LiO
- ☐ 2LiO
- ☐ Li_2O
- ☐ Li_2O_2
- ☐ $3LiO_2$

Li_2O

35.

We can use the symbols of the elements to indicate that a chemical change has taken place. LOOK AT the shorthand statement below.

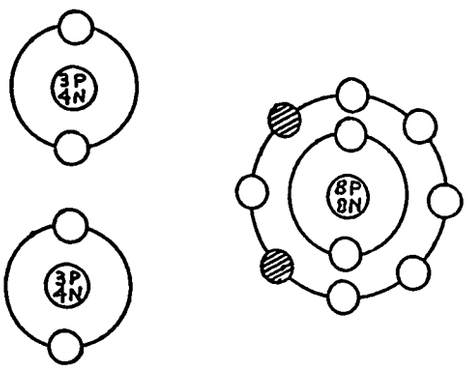
$$2Mg + O_2 \longrightarrow 2MgO^*$$

Now, MATCH the columns below:

A. 2Mg	1. _____	2 atoms of magnesium	1. A
B. +	2. _____	1 elemental molecule containing 2 atoms of oxygen	2. C
C. O_2			
D. $\longrightarrow$	3. _____	plus	3. B
E. 2MgO	4. _____	yields or is converted to .	4. D
	5. _____	2 molecules of magnesium oxide	5. E

*Notice that we only need 1 magnesium atom to react with 1 oxygen atom; but oxygen never exists as a single atom, thus we need 2 magnesium atoms to unite with it. (O_2, however, does not refer to a compound, it refers to an element.) Thus, the reaction yields 2 molecules.

PANEL 3



32.

When we want to refer to more than one atom of an element, we put a number in front of the symbol: 2C represents 2 carbon atoms.

When a molecule has more than one atom of a given element, the number is indicated to the right of and slightly lower than the symbol of the element: CCl_4 represents a molecule of 1 carbon atom and 4 chlorine atoms.

We can indicate more than one molecule by placing a number before the chemical formula: $6CCl_4$ represents 6 molecules, each one of which has 1 carbon atom and 4 chlorine atoms.

MATCH the columns below:

A. 2Na	1. _____ 2 atoms of the same element that are not a part of a molecule	1. A
B. O_2		
C. 2NaCl	2. _____ 2 atoms of the same element that are a part of a molecule	2. B*
	3. _____ 2 molecules	3. C

*Recall that oxygen never exists in an uncombined state as a single atom but always as an elemental molecule.

PM 431-24

ADVANCED GENERAL EDUCATION PROGRAM

A HIGH SCHOOL SELF-STUDY PROGRAM

FORMS OF ENERGY
LEVEL: I
UNIT: 7
LESSON: 3

U.S. DEPARTMENT OF LABOR
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NOVEMBER 1969

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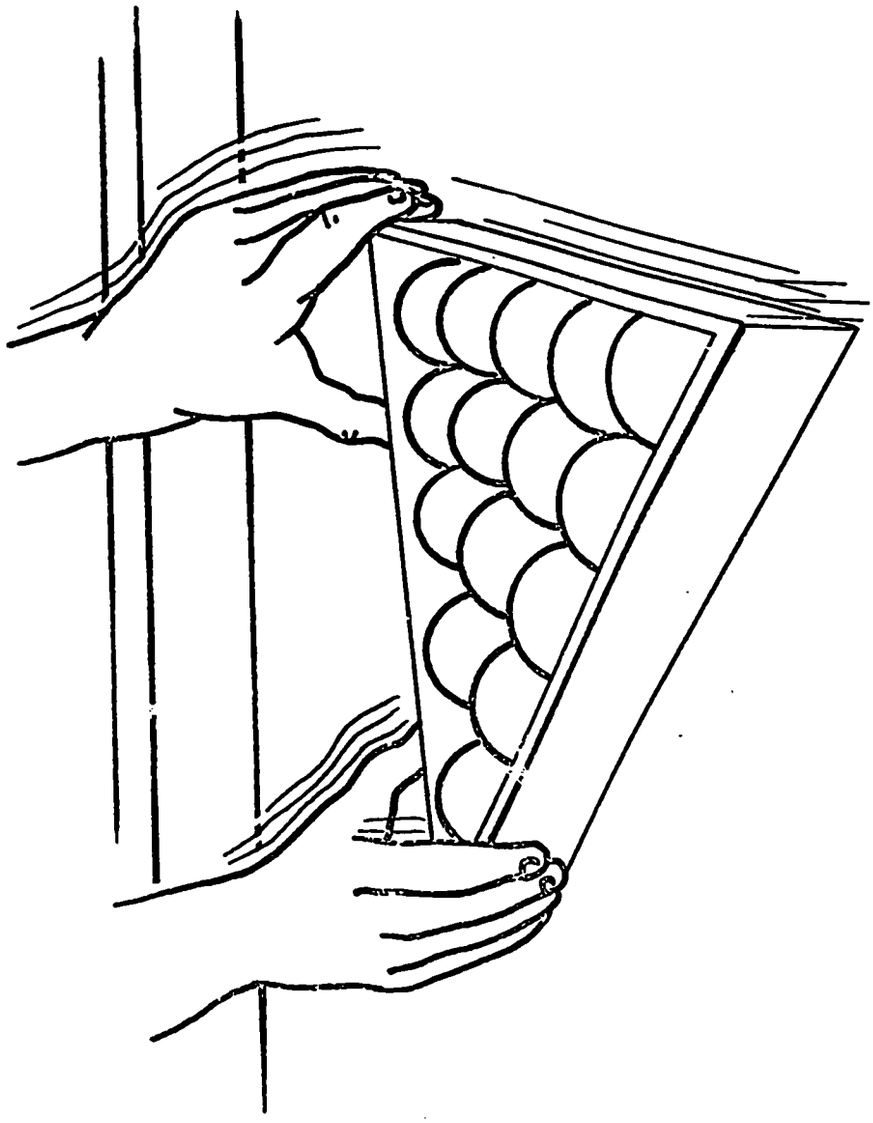
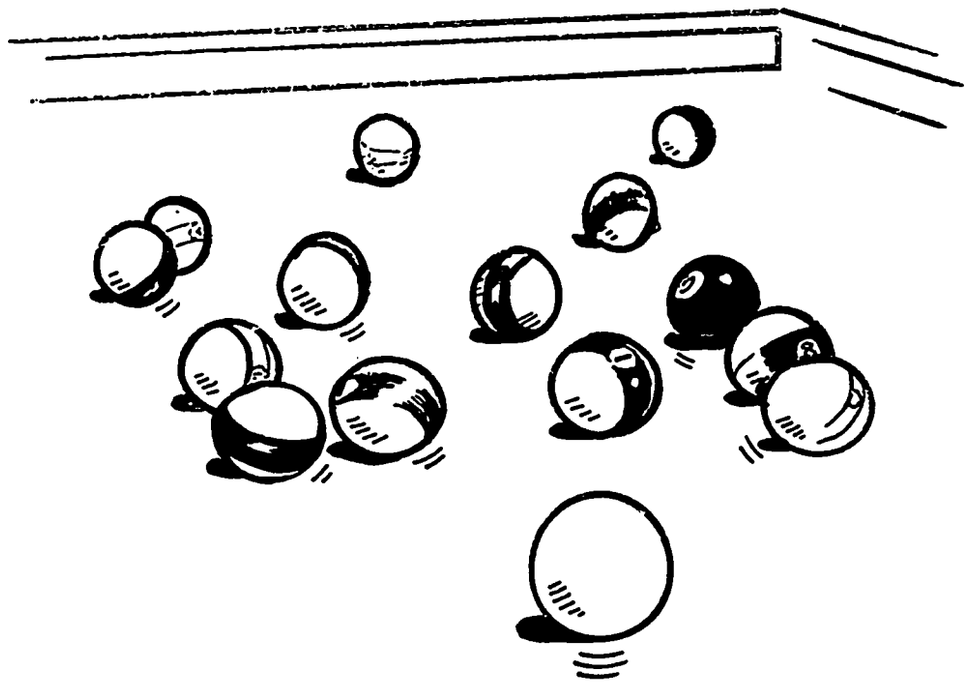


PANEL 1

PANEL 2



1. PREVIEW FRAME In a previous lesson, you learned that energy is that which has the ability to move matter. We briefly discussed 4 forms of energy: heat, light, sound, and electricity; and gave you examples of each form moving some kind of matter. It was probably very difficult for you to separate the idea of what energy actually is from the matter it was moving. We are so used to considering energy in terms of the effect that it can produce. In this lesson, you will learn more about the forms energy can take and how energy is transferred even through space. After the lesson, you will have a better understanding not only of the distinction between matter and energy but also their relationship, which is the basis of all phenomena. NO RESPONSE REQUIRED	GO ON TO THE NEXT FRAME
2. REFER TO PANELS 1 AND 2 **(Pages 1 and 2).** The first Panel shows a group of billiard balls in a form being moved across a billiard table, and the second Panel shows the billiard balls being struck by a cue ball. When the billiard balls are being moved across the table in a form, they move: ☐ in different directions ☐ in the same direction ☐ at different speeds ☐ at the same speed When the billiard balls are struck by the cue ball, they move: ☐ in different directions ☐ in the same direction ☐ at different speeds ☐ at the same speed	in the same direction at the same speed in different directions at different speeds

3. When objects in a group move in the same direction and at the same speed, their movement is said to be <u>ordered</u>. When objects move in different directions and at different speeds, their movement is said to be <u>random</u>. The movement of billiard balls in a form across a billiard table is: ☐ ordered ☐ random The movement of billiard balls after they have been struck by a cue ball is: ☐ ordered ☐ random	ordered random
4. Ordered movement refers to the movement of objects: ☐ in different directions ☐ in the same direction ☐ at different speeds ☐ at the same speed Random movement refers to the movement of objects: ☐ in different directions ☐ in the same direction ☐ at different speeds ☐ at the same speed	in the same direction at the same speed in different directions at different speeds

5.

Suppose that a group of people inside a moving bus are continually standing up, sitting down, and moving around in the aisle.

Consider the movement of the people in relation to one another and in relation to objects outside the bus.

In relation to objects outside the bus, the people are moving:

- ☐ at different speeds and in different directions
- ☐ at the same speed and in the same direction

at the same speed and in the...

In relation to one another, the people are moving:

- ☐ at different speeds and in different directions
- ☐ at the same speed and in the same direction

at different speeds and in . . .

Thus, in relation to objects outside the bus, the people are moving:

- ☐ in a random way
- ☐ in an ordered way

in an ordered way

In relation to one another, the people are moving:

- ☐ in a random way
- ☐ in an ordered way

in a random way

5. MATCH the form of energy with the reactions with which they are associated.

A. chemical energy	1. _____ analysis
B. nuclear energy	2. _____ fission
	3. _____ fusion
	4. _____ synthesis

Time completed _____

WHEN YOU HAVE FINISHED THIS TEST, WRITE DOWN THE TIME. THEN TAKE THE LESSON TO YOUR INSTRUCTOR OR HIS ASSISTANT FOR CHECKING. WAIT UNTIL THE LESSON IS APPROVED BEFORE GOING ON TO THE NEXT LESSON.

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6. Since the bus is moving, the people inside are moving both in relation to one another and in relation to objects outside the bus. When the bus stops moving, however, the people are moving only in relation to one another. Thus, when the bus is moving, the movement of the people inside is: ☐ ordered only ☐ random only ☐ both random and ordered When the bus is standing still, the movement of the people inside is: ☐ ordered only ☐ random only ☐ both random and ordered	both random and ordered random only
7. The molecules inside a body of matter are like the people inside the bus. That is, the molecules inside a body of matter are in random movement, whether the body is standing still or moving from one place to another. But, in addition, when the body of matter is moving from one place to another, the molecules inside are moving in an ordered way in relation to objects outside the body. Thus, molecules move in a random way inside a body of matter that is: ☐ moving from one place to another ☐ standing still Molecules move in an ordered way inside a body of matter that is: ☐ moving from one place to another ☐ standing still	moving from one place to another standing still moving from one place to another

1. The molecules of a falling leaf are moving:

   a. ☐ in an ordered way only

   b. ☐ in a random way only

   c. ☐ in both a random and an ordered way

   d. ☐ not at all

2. MATCH the forms of energy with the means by which they are transferred:

A. heat	1. _____ conduction
B. light	2. _____ convection
C. sound	3. _____ waves transferred by the molecules of matter
	4. _____ waves that are not transferred by the molecules of matter

3. Electricity may take the form of:

   a. ☐ a flow of electrons

   b. ☐ static charges

   c. ☐ neither of the above

4. Electric charges are produced only by atoms forming ionic bonds.

   a. ☐ true

   b. ☐ false

8. When a body of matter is at rest, its molecules move: ☐ in a random way only ☐ in an ordered way only ☐ in both an ordered and a random way When a body of matter is moving from one place to another, its molecules move: ☐ in a random way only ☐ in an ordered way only ☐ in both an ordered and a random way	in a random way only in both an ordered and . . .
9. In a previous lesson, you learned that energy is the ability to move matter. When a molecule in random or ordered motion collides with another molecule, the latter molecule is also caused to move. Thus, a molecule in random motion: ☐ can move another molecule ☐ cannot move another molecule and a molecule in ordered motion: ☐ can move another molecule ☐ cannot move another molecule Therefore, the random movement of a molecule: ☐ is a form of energy ☐ is not a form of energy and the ordered movement of a molecule: ☐ is a form of energy ☐ is not a form of energy	can move another molecule can move another molecule is a form of energy is a form of energy

MASTERY TEST

Time started _____

10. Energy may take the form of the: ☐ ordered movement of molecules ☐ random movement of molecules	 ordered movement of molecules random movement of molecules
11. As you know, when we apply heat to a body of matter, we increase the random movement of its molecules. For this reason, the random movement of molecules is called <u>heat energy</u>. Bodies of matter moving from one place to another were first studied by scientists in connection with the movements of parts of a machine. For this reason, such movements were called mechanical movements; and the ordered movement of the molecules of a body of matter moving from one place to another is called <u>mechanical energy</u>. A warm glass of milk and a cold orange are examples of: ☐ heat energy ☐ mechanical energy A glass of milk falling from the top of a table and an orange rolling across the table are examples of: ☐ heat energy ☐ mechanical energy	 heat energy heat energy mechanical energy

V. ELECTRICAL ENERGY	two basic kinds of electricity are electric current and static electric charge
A. ELECTRIC CURRENT	a <u>flow of electrons</u> from one point in a conductor to another
	EXAMPLE: electrical energy flows from a wall outlet, through a wire (conductor), to a lamp
1. CONDUCTOR	a substance through which electrons can flow freely
B. STATIC ELECTRIC CHARGES OR STATIC ELECTRICITY	an excess of electrons collected on a surface of an object which <u>tend to stay there</u>
	EXAMPLE: rubbing a piece of silk on a glass rod causes a transfer of electrons from the glass to the silk; the silk becomes negatively charged (an excess of electrons)
VI. CHEMICAL ENERGY	energy that is absorbed or liberated during a chemical reaction (synthesis or analysis)
VII. NUCLEAR ENERGY	two forms of nuclear energy are fusion and fission
A. FUSION	the <u>uniting</u> of two atoms to form a larger one
B. FISSION	the <u>dividing</u> of an atom into smaller ones

12. All molecules move: ☐ at least in a random way ☐ but also in an ordered way All matter has: ☐ at least heat energy ☐ but also mechanical energy All bodies of matter moving from one place to another have: ☐ at least heat energy ☐ but also mechanical energy	at least in a random way at least heat energy at least heat energy but also mechanical energy
13. Compare mechanical energy and heat energy, by MATCHING the columns below: A. ordered movement of the molecules B. random movement of the molecules C. of a body at rest D. of a body moving from one place to another 1. _____ heat energy 2. _____ mechanical energy	1. B, C, D 2. A, D

ORDERED MOVEMENT	objects moving in the same direction at the same speed
RANDOM MOVEMENT	objects moving in different directions at different speeds
FORMS OF ENERGY	there are many forms of energy; the major forms are: heat, mechanical, sound, light, electric, chemical, nuclear
I. HEAT ENERGY	the random movement of molecules inside a body of matter
A. CONDUCTION	the transfer of heat energy by the flow from molecule to molecule in a solid substance
	EXAMPLE: an iron pole is heated on one end; soon the entire pole becomes heated
B. CONVECTION	the transfer of heat by the circulation of groups of molecules in a liquid or a gas
	EXAMPLE: a radiator is able to heat an entire room
C. RADIATION	the transfer of heat by the movement of waves of unknown composition
	EXAMPLE: heat from the sun is able to heat the earth
II. MECHANICAL ENERGY	the ordered movement of the molecules of a body of matter moving from one place to another
III. SOUND ENERGY	waves composed of matter that can cause a person to hear
IV. LIGHT ENERGY	waves of unknown composition that can cause a person to see

14. When a moving body collides with another body (for now, assume that the bodies have the same weight and volume), the latter body also begins to move; and it, in turn, can cause another body to move if there is a collision. Thus, mechanical energy: ☐ can be transferred ☐ cannot be transferred When a cold substance is placed in contact with, or in the vicinity of, a hot substance, the cold substance becomes warmer, and vice versa. Or, if one part of a cold substance is heated, other parts of the substance also become warm. Thus, heat energy: ☐ can be transferred ☐ cannot be transferred	can be transferred can be transferred
15. PREVIEW FRAME In the following frames, we will discuss the transfer of heat energy. The transference of mechanical energy will be taken up in later lessons. NO RESPONSE REQUIRED	GO ON TO THE NEXT FRAME
16. When one end of a needle is heated with a lighted match, the other end of the needle also becomes hot. In some way that scientists do not completely understand, heat flows from molecule to molecule of a solid substance. When the handle of a pot on a stove burner becomes hot, a flow from molecule to molecule has: ☐ resulted in a transfer of heat ☐ not resulted in a transfer of heat	resulted in a transfer of heat

63.

Compare nuclear energy and chemical energy by MATCHING the columns below:

A. energy absorbed or liberated during analysis	1. ____ chemical energy	1. A, B
B. energy absorbed or liberated in synthesis	2. ____ nuclear energy	2. C, D
C. energy absorbed or liberated in fission		
D. energy absorbed or liberated during fusion		

Time completed _____

YOU HAVE NOW FINISHED THE FIRST PART OF THIS LESSON. WRITE DOWN THE TIME. THEN, AFTER YOU HAVE REVIEWED THE MAIN IDEAS IN THE FOLLOWING SUMMARY, TAKE THE MASTERY TEST AT THE END OF THE BOOKLET.

17. When a radiator is turned on, the air around it is heated. Consequently, its molecules begin to move more rapidly and farther apart; that is, the air expands and becomes lighter. As it becomes lighter the warm air rises to the top of the room and takes the place of the colder air which sinks and thus takes a place nearer the radiator. Soon, this air is also heated. The process continues until all the air in the room is warm. When a pot of water is put on a hot stove, the water at the bottom of the pot expands and becomes lighter as its molecules move faster and farther apart. The colder water on top, being heavier, sinks to the bottom of the pot, and the warmer water rises to the top. This circulating movement of the groups of molecules of the warmer and cooler water soon heats all the water in the pot. The circulating movement of groups of warmer and cooler molecules of a liquid or gas: ☐ does not result in a transfer of heat ☐ results in a transfer of heat	results in a transfer of heat
18. The sun is separated from earth by millions of miles of empty space. Yet the heat of the sun warms the earth. As far as is known, there is no matter in outer space; consequently, heat in outer space does not appear to involve molecules. Scientists have discovered that the heat given off by the sun travels in the form of waves. These waves do not need matter as their means of transfer. Waves that are not transferred by molecules of matter: ☐ can result in the transfer of heat ☐ cannot result in the transfer of heat	can result in the transfer of heat

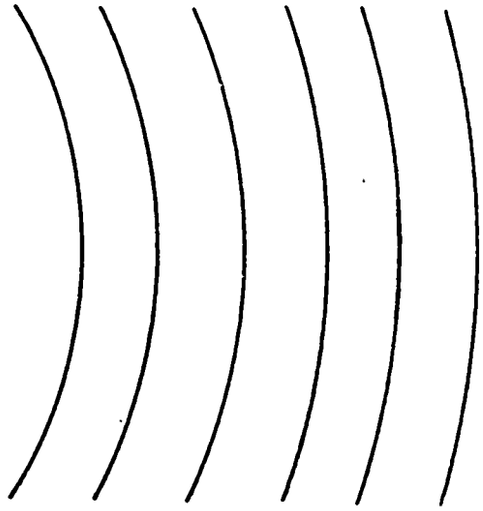
61. During a nuclear reaction, whether fission or fusion, great amounts of heat, light and sound are produced. Such energy is called <u>nuclear</u> energy. Energy produced during any other process is not called nuclear energy. Which of the following are examples of nuclear energy? ☐ heat produced by a radiator ☐ heat produced when two atoms unite to form one larger one ☐ light produced by a fire ☐ light produced when one atom divides to form 2 smaller ones ☐ sound produced by the clapping of hands	heat produced when two . . . light produced when one . . .
62. Energy may be produced by: ☐ a chemical reaction. ☐ a nuclear reaction	a chemical reaction a nuclear reaction

19. Heat can be transferred through: ☐ empty space ☐ a gas ☐ a liquid ☐ a solid	 empty space a gas a liquid a solid
20. Heat can be transferred by: ☐ the circulation of groups of warmer and cooler molecules ☐ flowing from molecule to molecule ☐ waves that do not involve the molecules of matter	 the circulation of groups of . . . flowing from molecule to . . . waves that do not involve . . .
21. When heat is transferred by flowing from molecule to molecule in a solid substance, it is called <u>conduction</u>. When heat is transferred by the circulation of groups of molecules in a liquid or gas, it is called <u>convection</u>. When heat is transferred by waves that do not involve the molecules of matter, it is called <u>radiation</u>. MATCH the columns below to indicate an example of each type of heat transfer: A. a pot of milk boils B. an entire crowbar becomes hot when one end is heated C. the earth is warmed by the heat of the sun 1. _____ conduction 2. _____ convection 3. _____ radiation	 1. B 2. A 3. C

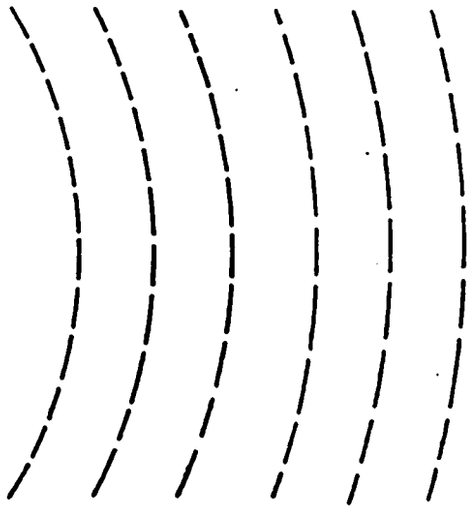
58. Both the process of fusion and the process of fission are called <u>nuclear reactions</u>. REFER TO PANEL 5 Drawing 1: ☐ does not illustrate a nuclear reaction ☐ illustrates a nuclear reaction Drawing 2: ☐ does not illustrate a nuclear reaction ☐ illustrates a nuclear reaction	 illustrates a nuclear reaction illustrates a nuclear reaction
59. Fusion refers to: ☐ the uniting of two atoms to form a larger atom ☐ the division of an atom into smaller atoms and fission refers to: ☐ the uniting of two atoms to form a larger atom ☐ the division of an atom into smaller atoms	 the uniting of two atoms . . . the division of an atom . . .
60. A nuclear reaction may consist of: ☐ fission ☐ fusion	 fission fusion

22. CHECK the types of heat transfer below: ☐ conduction ☐ convection ☐ radiation	conduction convection radiation
23. MATCH the columns below to indicate the definition of each type of heat transfer: A. the flow from molecule to molecule of a solid substance B. waves that do not involve the molecules of matter C. circulation of groups of molecules in a liquid or gas 1. _____ conduction 2. _____ convection 3. _____ radiation	1. A 2. C 3. B
24. As you know, heat waves are not transferred by the molecules of matter. Other such waves are X-rays and infrared rays. By contrast, ocean waves are waves which depend on the molecules of matter. Other waves, which are transferred by the molecules of matter, are the waves that are made by a taut string when it is plucked, or the waves that a ruler makes when it is held at one end and snapped. In general, waves may: ☐ be transferred by the molecules of matter ☐ be transferred in the absence of matter	be transferred by the mole- . . . be transferred in the absence . . .

PANEL 3



DRAWING 1



DRAWING 2

25.

REFER TO PANEL 3 (Page 14)

Waves can be represented by a series of curved lines, as shown on Panel 3. Waves that are transferred by molecules of matter can be represented by solid lines, and waves that are not transferred by the molecules of matter can be represented by dotted lines.

The waves shown in Drawing 1 on Panel 3 are:

- ☐ waves transferred by the molecules of matter
- ☐ waves that are not transferred by the molecules of matter

The waves shown in Drawing 2 are:

- ☐ waves transferred by the molecules of matter
- ☐ waves that are not transferred by the molecules of matter

waves transferred by the . . .

waves that are not . . .

26.

REFER TO PANEL 4 (Page 16).

Panel 4 shows four different waves. Also shown is the effect each type of wave has on a person.

According to the panel, the first type of wave:

- ☐ causes a person to hear
- ☐ causes a person to see
- ☐ has no effect on a person

has no effect on a person

The second type of wave:

- ☐ causes a person to hear
- ☐ causes a person to see
- ☐ has no effect on a person

causes a person to hear

The third type of wave:

- ☐ causes a person to hear
- ☐ causes a person to see
- ☐ has no effect on a person

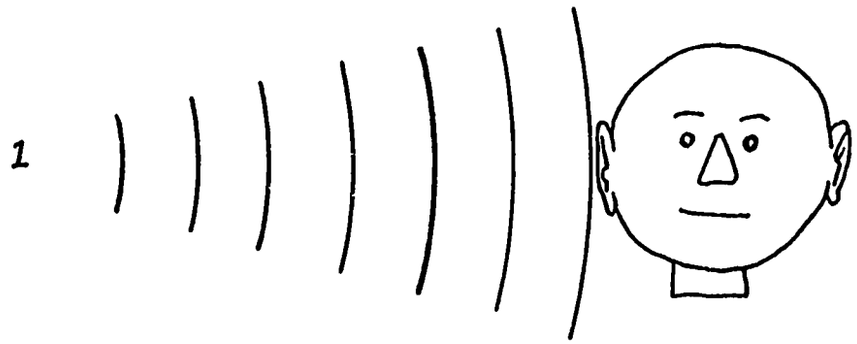
has no effect on a person

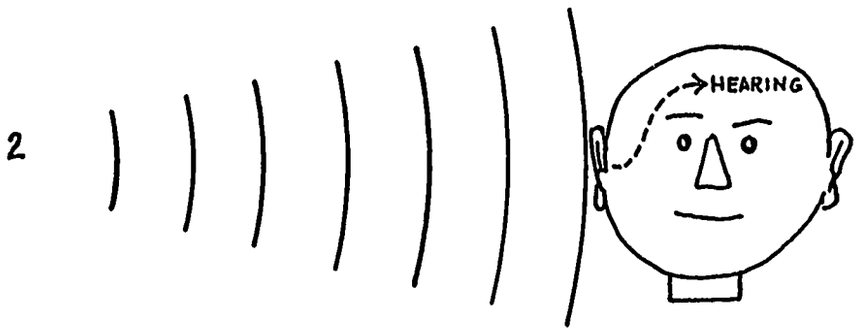
The fourth type of wave:

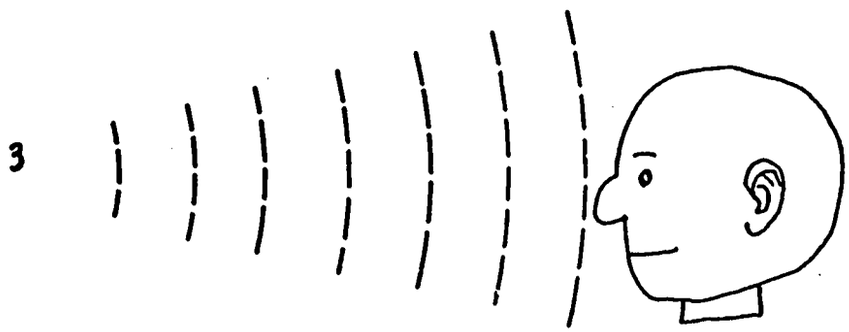
- ☐ causes a person to hear
- ☐ causes a person to see
- ☐ has no effect on a person

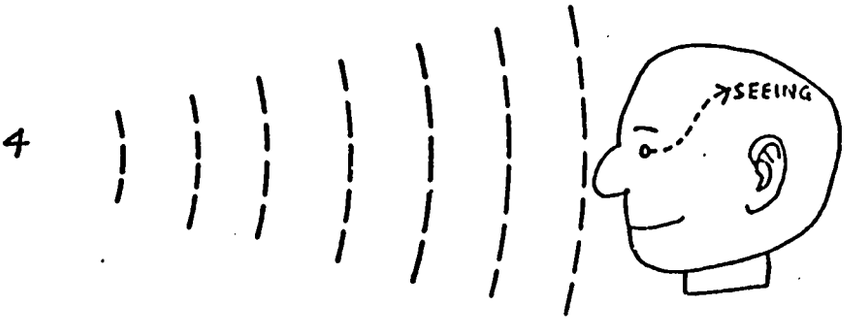
causes a person to see

PANEL 4





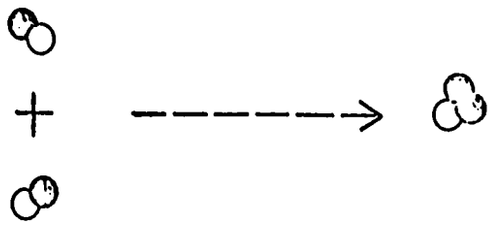




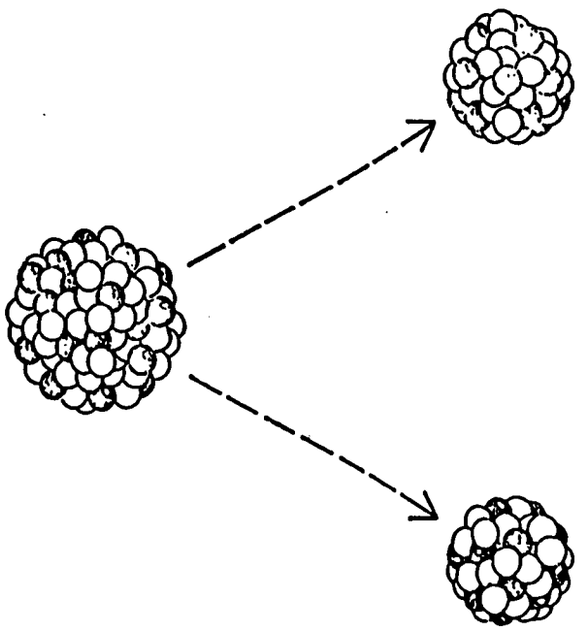
27. REFER TO PANEL 4 The type of wave that causes hearing is a: ☐ wave transferred by the molecules of matter ☐ wave that is not transferred by the molecules of matter The type of wave that causes seeing is a: ☐ wave transferred by the molecules of matter ☐ wave that is not transferred by the molecules of matter	wave transferred by the . . . wave that is not transferred . . .
28. REFER TO PANEL 4 Hearing is caused by: ☐ any waves transferred by the molecules of matter ☐ some waves transferred by the molecules of matter Seeing is caused by: ☐ any waves that are not transferred by the molecules of matter ☐ some waves that are not transferred by the molecules of matter	some waves transferred . . . some waves that are not . . .
29. Waves transferred by the molecules of matter that can cause a person to hear are called <u>sound</u>. Waves that are not transferred by the molecules of matter that can cause a person to see are called <u>light</u>. REFER TO PANEL 4 Sound is illustrated by the drawing of the: ☐ first type of wave ☐ second type of wave ☐ third type of wave ☐ fourth type of wave Light is illustrated by the drawing of the: ☐ first type of wave ☐ second type of wave ☐ third type of wave ☐ fourth type of wave	second type of wave fourth type of wave

55. Chemical changes involve the: ☐ electrons in the innermost orbit ☐ electrons in the middle orbits ☐ electrons in the outermost orbit ☐ the protons and neutrons in the nucleus	electrons in the outermost orbit
56. Changes occur in atoms that also involve the protons and neutrons in the nucleus. For example, one large atom may divide into two smaller atoms. Also, two smaller atoms may unite to form one larger atom. REFER TO PANEL 5 (Page 27). Drawing 1 shows 2 atoms: ☐ dividing into smaller atoms ☐ uniting to form a larger atom Drawing 2 shows an atom: ☐ dividing into smaller atoms ☐ increasing in size	uniting to form a larger atom dividing into smaller atoms
57. When two atoms unite to form a larger one, the process is called <u>fusion</u>. When an atom divides into smaller atoms, the process is called <u>fission</u>. Both fission and fusion are nuclear reactions. REFER TO PANEL 5 Drawing 1 illustrates the process of: ☐ fission ☐ fusion Drawing 2 illustrates the process of: ☐ fission ☐ fusion NOTE: Skip two(2) pages to find page 29.	fusion fission

PANEL 5



DRAWING 1



DRAWING 2

53.

When energy is required to unite elements, it is said to be absorbed by the resulting compound, and when the compound is subsequently broken down, the energy is said to be liberated (freed).

By contrast, when energy is required to break down a compound, it is absorbed by the elements, and when the elements reunite, the energy is liberated.

Energy may be absorbed during:

- ☐ analysis
- ☐ synthesis

and it may be liberated during:

- ☐ analysis
- ☐ synthesis

analysis
synthesis

analysis
synthesis

54.

Energy that is absorbed or liberated during a chemical reaction is called chemical energy.

Energy required or produced by any other process is not chemical energy.

Which of the following are examples of chemical energy?

- ☐ heat given off during the formation of a compound
- ☐ heat given off when two objects are rubbed together
- ☐ light given off by the sun
- ☐ light given off during the breakdown of a compound
- ☐ sound given off by a loudspeaker
- ☐ sound given off during the breakdown of a compound

heat given off during the . . .

light given off during the . . .

sound given off during the . . .

30. Sound is: ☐ any waves which are transferred by the molecules of matter ☐ waves which are transferred by the molecules of matter that can cause a person to hear ☐ waves which are not transferred by the molecules of matter that can cause a person to hear Light is: ☐ any waves which are transferred by the molecules of matter ☐ waves which are transferred by the molecules of matter that can cause a person to see ☐ waves which are not transferred by the molecules of matter that can cause a person to see	waves which are transferred . . . waves which are not . . .
31. Sound waves can pass through air, or water, or walls. Thus, sound waves can pass through: ☐ one kind of matter only ☐ many kinds of matter	many kinds of matter
32. When sound waves reach a person's ear, they cause the ear drum to vibrate back and forth. Thus, sound waves: ☐ can move matter ☐ cannot move matter Therefore, sound: ☐ is a form of energy ☐ is not a form of energy	can move matter is a form of energy

51. In a previous lesson, you learned that synthesis is the combining of elements to form a compound, and that analysis is the breaking up of compounds into their constituent elements. A chemical reaction may consist of: ☐ analysis ☐ synthesis	 analysis synthesis
52. In order for certain elements to unite to form a compound, they must first be heated. If this compound is later broken down, the same amount of energy is given off, usually in the form of heat, but sometimes also in the form of light and sound. In the case of other elements, the formation of a compound produces heat, and sometimes light and sound. In such cases, the breakdown of the compound requires heat. Thus, the formation of a compound: ☐ may produce energy ☐ may require energy and the breakdown of a compound: ☐ may produce energy ☐ may require energy	 may produce energy may require energy may produce energy may require energy

33. When light waves reach a person's eye, they cause certain substances in the back of the eye to be re-arranged, that is, be moved in a special way. Thus, light waves: ☐ can move matter ☐ cannot move matter Therefore, light: ☐ is a form of energy ☐ is not a form of energy	 can move matter is a form of energy
34. Energy may take the form of: ☐ light waves ☐ sound waves	 light waves sound waves
35. Compare light energy and sound energy by MATCHING the columns below: A. causes a person to hear B. causes a person to see C. transferred by the molecules of matter D. waves E. not transferred by the molecules of matter 1. _____ light energy 2. _____ sound energy	 1. B, D, E 2. A, C, D

48. A light beam can be used to trigger the movement of an automatic door. When light is concentrated by a magnifying glass, it can start a fire. The light passing through the sound track of a movie film causes an electric current which in turn produces sound. Thus, light energy can be transformed, directly or indirectly, into: ☐ electrical energy ☐ heat energy ☐ mechanical energy ☐ sound energy ☐ none of the above	electrical energy heat energy mechanical energy sound energy
49. Of the various forms of energy, sound is the one which is least often transformed into other forms of energy. Nevertheless, very loud sound can shatter glass (movement of a body from one place to another) and sound of very high pitch and intensity can be used to heat substances. The sound of our voices can be changed by a radio microphone into electric signals. As you know, electricity can produce light. Thus, sound energy can be transformed, directly or indirectly, into: ☐ electrical energy ☐ heat energy ☐ light energy ☐ mechanical energy ☐ none of the above	electrical energy heat energy light energy mechanical energy
50. In general, a form of energy can usually be transformed into: ☐ every other form of energy ☐ no other form of energy ☐ only one or two other forms of energy	every other form of energy

36. REVIEW FRAME An ionic bond is formed when electrons are: ☐ transferred ☐ shared When electrons are transferred: ☐ electrons are lost ☐ electrons are gained ☐ neither of the above When electrons are lost: ☐ a negatively charged ion is formed ☐ a positively charged ion is formed When electrons are gained: ☐ a negatively charged ion is formed ☐ a positively charged ion is formed	transferred electrons are lost electrons are gained a positively charged ion . . .
37. When a glass rod is rubbed with silk, the electrons pass from the glass rod to the silk; the rod becomes positively charged and the silk becomes negatively charged. Neither the silk nor the glass rod is chemically changed. A negatively charged substance may be the result of: ☐ a chemical reaction only ☐ rubbing two kinds of matter together	a negatively charged ion . . . rubbing two kinds of . . .
38. When an excess of electrons are collected on the surface of an object and tend to stay there, they are called <u>static charges</u> or <u>static electricity</u>. The charge produced on the piece of silk mentioned in the previous frame: ☐ is an example of static electricity ☐ is not an example of static electricity	is an example of static . . .

45. Electricity is used to run machines, to operate toasters and ovens, to work lamps and to operate high fidelity systems. Thus, electrical energy can be transformed into: ☐ heat energy ☐ light energy ☐ mechanical energy ☐ sound energy ☐ none of the above	heat energy light energy mechanical energy sound energy
46. Machines, such as generators, can be used to produce electricity, which, as you have seen, can make light, heat or sound. In addition, the machines themselves become hot and make noise while they are running. Thus, mechanical energy can be transformed, directly or indirectly, into: ☐ electrical energy ☐ heat energy ☐ light energy ☐ sound energy ☐ none of the above	electrical energy heat energy light energy sound energy
47. Heat can be used to boil water. The steam thus produced can be used to run a steam generator, which produces electricity; and, to repeat again, from the electricity can come light and sound. Also, heat can produce sound directly, as happens when an explosion causes a sudden expansion of gases. Thus, heat energy can be transformed, directly or indirectly, into: ☐ electrical energy ☐ light energy ☐ mechanical energy ☐ sound energy ☐ none of the above	electrical energy light energy mechanical energy sound energy

39. Usually, however, electrons will flow from a point where there is an excess of electrons to a point where there is a deficiency of electrons. A substance through which electrons can flow freely is called a <u>conductor</u>. Electricity produced by a flow of electrons from one point in a conductor to another is called an <u>electric current</u>. Electricity produced by a flow of electrons from a source to an iron is an example of: ☐ an electric current ☐ static electricity	an electric current
40. MATCH the columns below: A. an excess of protons or an excess of electrons that tend to remain on an object B. a flow of electrons through a conductor from a point where there is an excess to a point where there is a deficiency 1. _____ electric current 2. _____ static electricity	1. B 2. A
41. The passage of an electric current through a machine causes the parts of a machine to move. Though this cannot be discussed at this time, it shows that electricity: ☐ can move matter ☐ cannot move matter Thus, electricity: ☐ is a form of energy ☐ is not a form of energy	can move matter is a form of energy

42. Energy: ☐ does not take the form of electricity ☐ may take the form of electricity	may take the form of electricity
43. REVIEW FRAME CHECK the other forms of energy below: ☐ heat ☐ light ☐ mechanical ☐ sound ☐ none of the above	heat light mechanical sound
44. REVIEW FRAME MATCH the following columns to indicate the definition of each form of energy: A. an excess of charges that tend to remain on an object, or a flow of electrons through a conductor from a point of an excess to a point of a deficiency B. waves which are transferred through matter that cause a person to hear C. waves which are not transferred through matter that cause a person to see D. ordered movement of the molecules of a body moving from one place to another E. random movement of the	1. _____ electricity 2. _____ heat energy 3. _____ light energy 4. _____ mechanical energy 5. _____ sound energy 1. A 2. E 3. C 4. D 5. B

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